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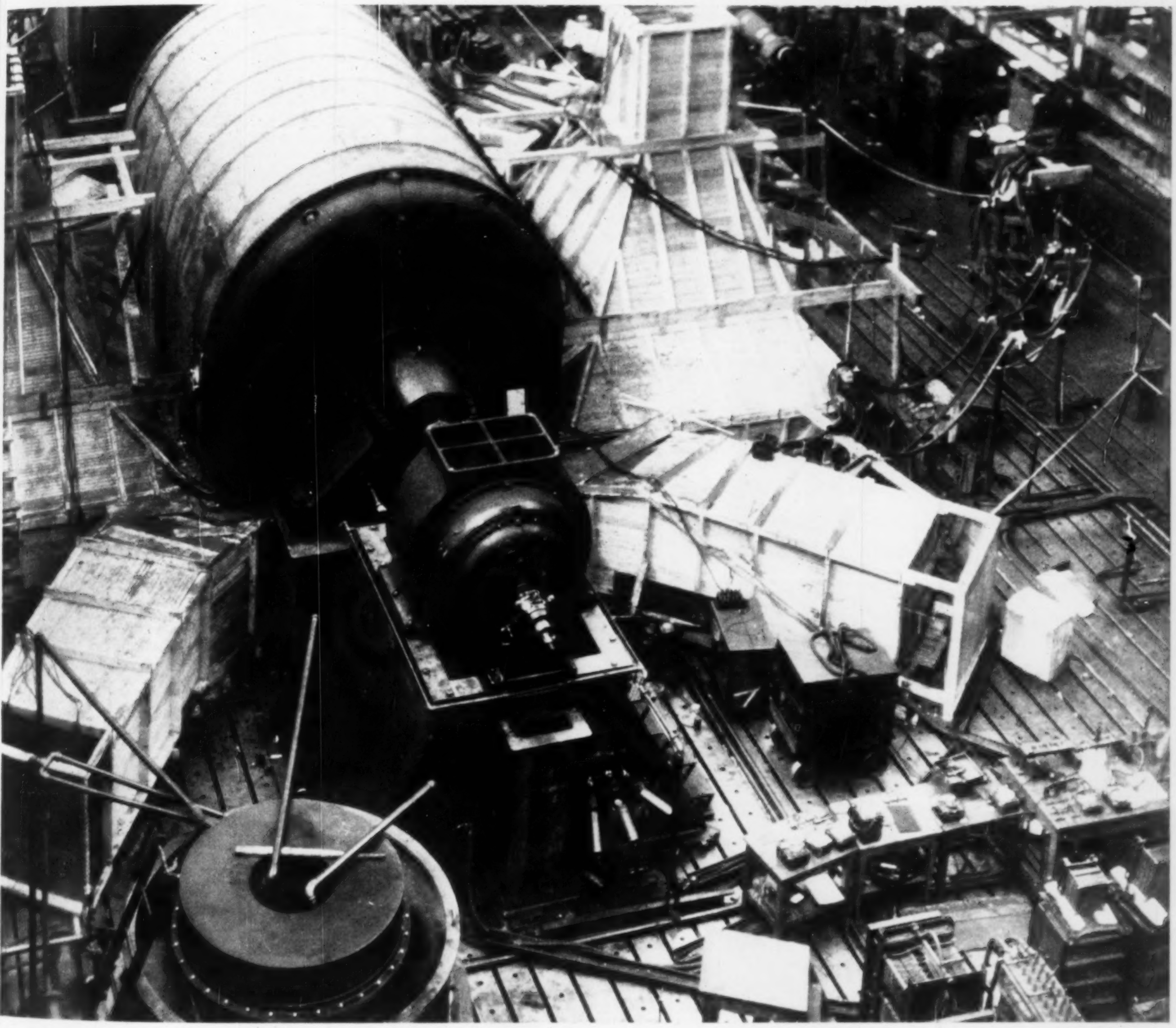
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 5 JUNE, 1932 NUMBER 6



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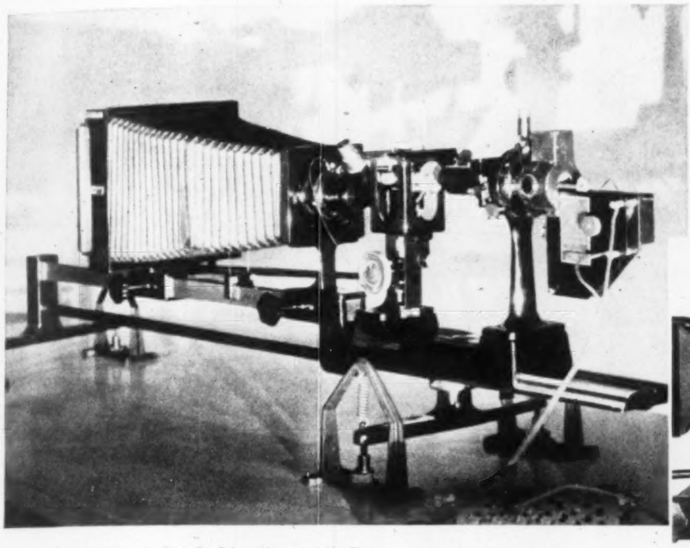

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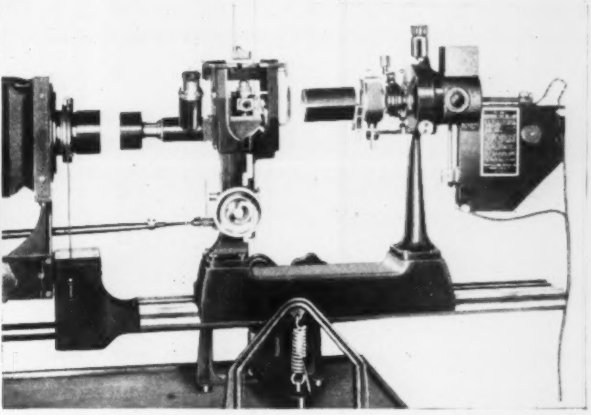

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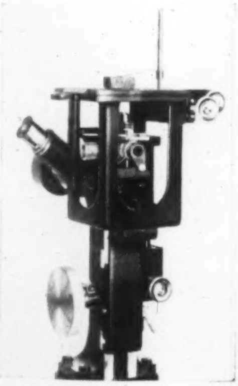

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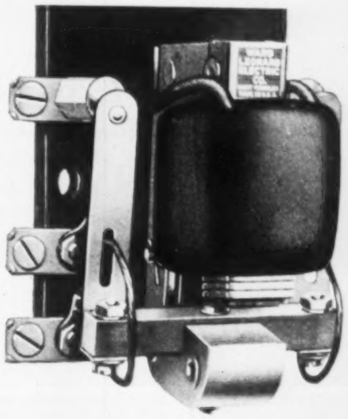

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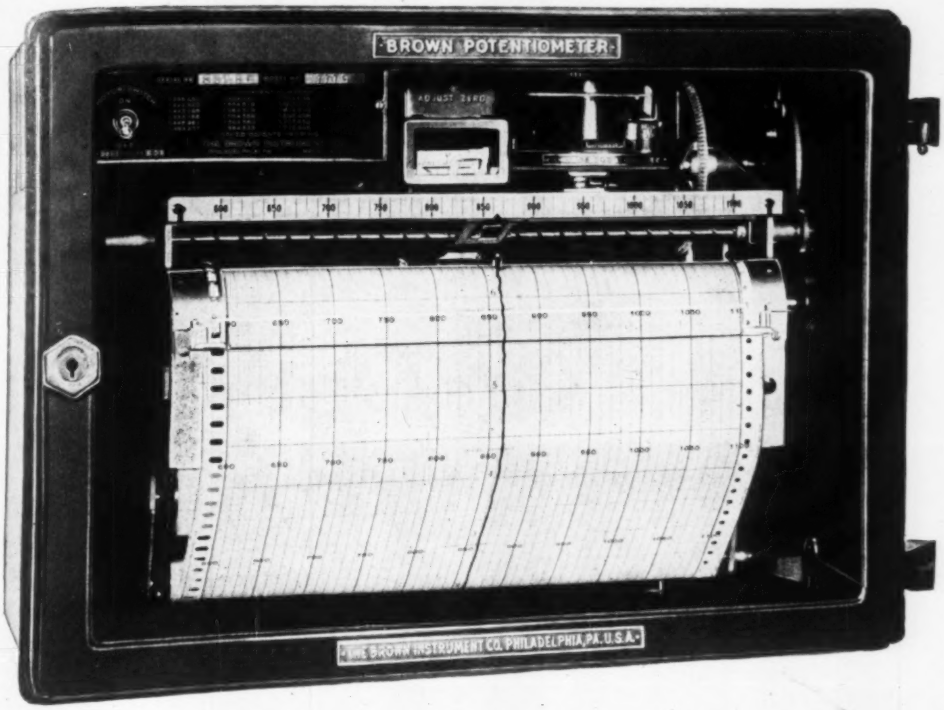

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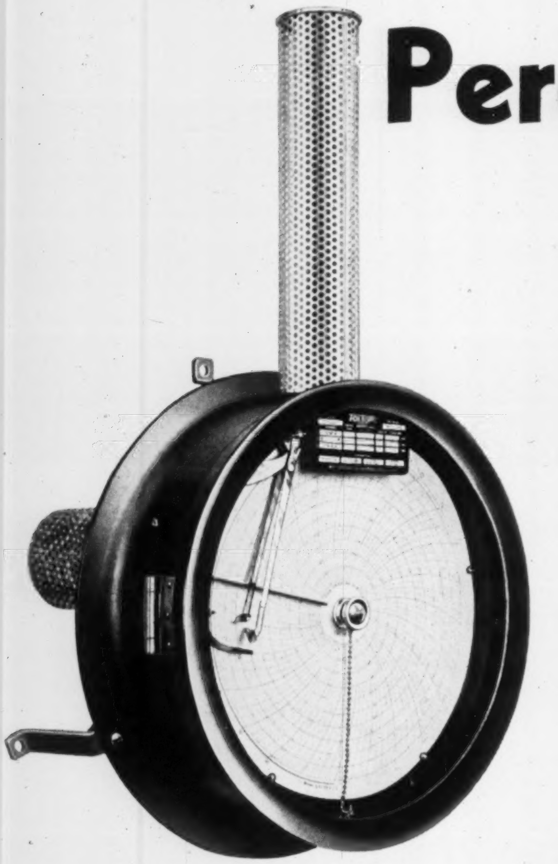

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EDITORIAL COMMENT

In This Issue

◆ **The Engine Indicator**—besides having "big brothered" the growth and development of prime movers from the earliest steam engine to the latest Diesel, is also father to a great field of pressure instruments. Its history is therefore an interesting background on pressure instruments and a particularly illuminating introduction to the further studies on the engine indicator which Prof. DeJuhasz will present monthly in INSTRUMENTS.

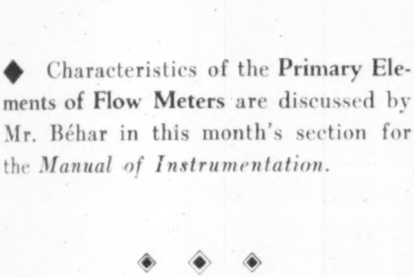
◆ A new moisture controlling instrument of great promise, which is highly sensitive and thoroughly practical, is the **Sensitive Wood-Element Hygrostat** described by Messrs. Loughborough and Rietz.

◆ Characteristics of the **Primary Elements of Flow Meters** are discussed by Mr. Béhar in this month's section for the *Manual of Instrumentation.*

◆ ◆ ◆

The Front Cover

◆ is a scene from the test floor of the Westinghouse Electric & Manufacturing Company when a full load test of a 68,750 kv-a generator is being carried out. Below is a close-up of the instrument set-up used by the engineers conducting the test.



On Appraisal

THIS is the sixth issue of INSTRUMENTS in its new form of larger size and increased editorial scope. The many improvements made have by now become distinctly evident. They are all worth consideration, so we list them:

1) The fields covered editorially by INSTRUMENTS have been increased to include that of electronics.

2) The scope of the fields covered has been broadened to include all components of the apparatus which performs the desired control functions—relays, valve mechanisms, switching apparatus, etc.

3) The articles have been increased in number, in size and in range of subjects covered.

4) Descriptions of new measuring and control devices in the New Instruments Section are more complete, and far more numerous.

5) Instruments Abstracts Section has been so developed that 56 abstractors now comb through over 700 publications, both foreign and domestic, for "current events" in measurement and control.

6) Also, the abstracts classification has been reorganized on the basis of "fields of reader interest," bringing all items related to your field of work under one heading, hence easy to find.

7) The Instruments Index, an index of measuring and controlling devices, listed so you can find quickly who makes them or where to get them, has been improved.

We trust that these improvements add to your approval of the publication, and invite your comments on the new INSTRUMENTS.

◆ ◆ ◆ ◆ ◆

Not "Cold Storage Stuff"

DUE to the completeness of Mr. Behar's treatments on flow meters and their appearance serially in INSTRUMENTS, an offhand impression might indicate that this part of The Manual of Instrumentation is cut-and-dried material prepared some time ago, but "kept in cold storage" so it can be released serially.

A close acquaintance with these articles will, however, dispel this notion and reveal that each installment is a current article, containing the very latest information obtainable up to the time of going to press.

THE DAM IS OUT

WHY don't modern dams give way—spreading the same horrifying disaster in their wake?

Why have aircraft accidents, due to structural weaknesses, decreased tremendously with this newest industry's growth?

Why don't modern railroad and highway bridges, subject to constantly increasing loads at higher speeds, fail under the strain?

How do bearing manufacturers diagnose the particular requirements of giant rolling mills?

Why don't modern automobiles line the roads with breakdowns, as they did only a few years ago?

To what great advancement in engineering do these and many more problems—commercial, scientific and industrial, that involve stresses in materials, accelerations, pressures and forces—owe their solution?

To man's measurement of stresses under dynamic conditions.

Arbitrary factors need no longer be asked to compensate for unknown effects.

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This instrument, a worthy member of the large Southwark family—headquarters for testing machines for all mechanical purposes—deserves your attention. Write for Bulletin No. 27, a complete description of the instrument, its auxiliary equipment and its application. Sent on request.

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The ENGINE INDICATOR

Its Design and Theory

By KALMAN J. DeJUHASZ*

INTRODUCTION

The indicator is an old and versatile engineering instrument. In its original conception it was intended to aid the development of the steam engine and in this field it has performed important services. The theory of the steam engine, and also that of the gas and oil engine, as well as of pumps and compressors, has been largely built up on information obtained by means of the indicator. In the development of our piston type prime movers from the wasteful, slow moving and heavy engines of a century ago into the economical, high speed and light engines of today the indicator has played a substantial part.

Essentially, the indicator is a recording pressure gage, by which the magnitude of variable pressures can be determined as a function of another variable. Usually the pressures are recorded on a piston displacement basis. The area of the chart thus obtained represents the work done by, or upon, the work medium. For some purposes it is preferable to record the pressures as a function of time, or crank angle. From characteristic points of the chart the stresses in the engine parts, the timing of the valve, throttling effect of too narrow steam pipes or insufficiently opening valves, leaking piston rings, on ignition and combustion phenomena, intake and exhaust phenomena, and other data important from a design or performance point of view, can be determined. All these faults mean losses in efficiency and in power output, as well as an unnecessarily rapid deterioration of the engine. The elimination of defects cuts down fuel and lubricating oil consumption, eliminates breakdowns and prolongs the life of the engine. By means of the indicator diagram overloading and underloading of the engine—both of which are uneconomical conditions—can be detected.

Also, an intelligently interpreted indicator card aids greatly in diagnosing engine trouble and points the way for its elimination.

Besides recording pressures as such, the indicator can be used for measuring variable forces, *i. e.*, in various forms of material testing equipment, or, in manufacturing processes involving the application of a hydraulic press. As an example of this latter application the process of pressing a pair of railway wheels on their axle by means of hydraulic pressure, may be mentioned. If the hydraulic pressure is recorded on the basis of hy-

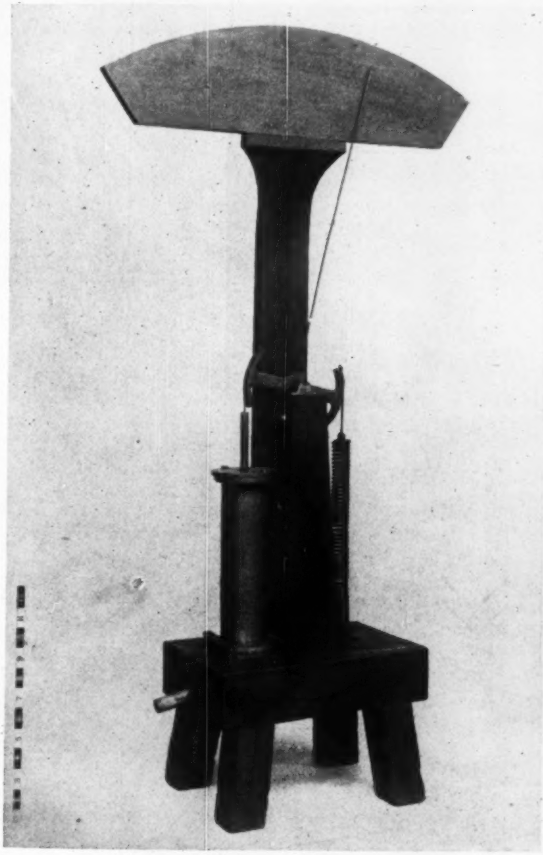


Fig. 1 Watt's Indicator (non-recording). This is one of the very earliest models which is preserved in the Science Museum (London). Note balance beam and spring in tension. Height of instrument approximately 30 in.

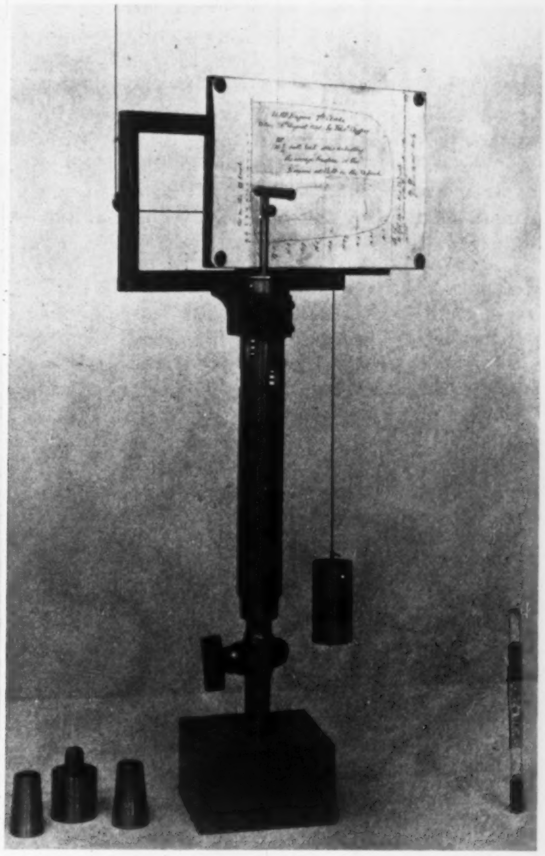


Fig. 2. Watt-Southern Recording Indicator, preserved in the Science Museum (London). This is the prototype of the present day indicator, containing all the essential elements. Note cock connection, spring in compression, pencil, sliding tablet, return weight. Height of instrument, approximately 20 in.

---

*Assistant Professor of Engineering Research, The Pennsylvania State College.

Editor's Note: This is the first article of a series.

Fig. 3. McNaught's Indicator, incorporating drum (with spiral spring) the first time. Note: separate cock, spring in compression, pencil moving in front of adjustable scale.

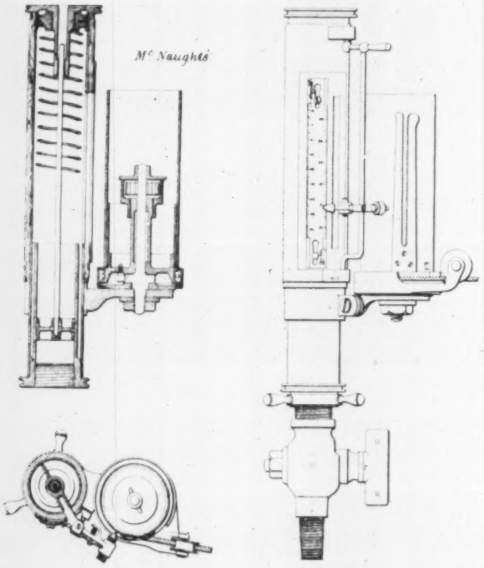
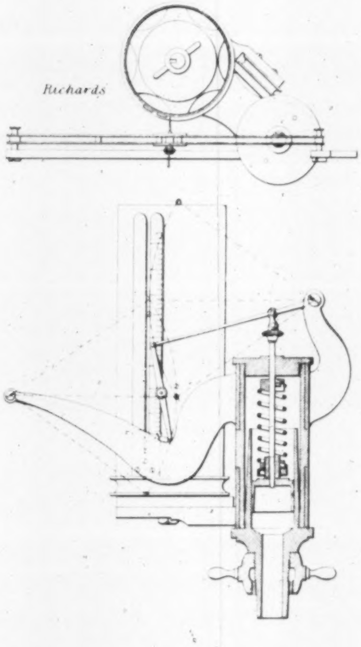


Fig. 4. Richards' Indicator incorporating a magnifying gear the first time. This is of the lemniscoid type involving somewhat heavy moving parts.



draulic ram displacement, by means of an indicator, the resulting chart shows the curve of pressures from start to finish and a poor fit is detected immediately. Such a record can be kept for future reference.

As a further application, the indicator can be adapted for recording a certain motion, such as the lift of an automatic suction or delivery valve, or the travel of a slide valve as a function of a certain other reference motion.

Owing to the wide variety of its uses the indicator is an indispensable piece of equipment in most engineering investigations involving the measurement of forces and motions. A great deal of ingenuity and painstaking research has been expended in bringing it to its present perfection and in adapting it to a great variety of purposes. Therefore its history, theory, construction and uses form a useful and fascinating study.

HISTORY OF THE INDICATOR

The indicator was originated by James Watt, the great improver of the steam engine, who as early as 1790, or shortly thereafter, conceived an instrument for showing the varying steam pressures inside the cylinder of his vacuum type engine. It consisted of a cylinder and within it a closely fitting, spring loaded piston. The rod of the latter carried a pointer movable over a fixed scale. It was not a recording instrument. When the cylinder of this instrument was brought into communication with the engine cylinder, the pressure change during a stroke could be observed, and, by watching the motion of some reciprocating part of the engine at the same time, the pressures at different points of the stroke could be noted. The engines of that period only used vacuum and ran at the low speed of 12-14 strokes per minute. No such apparatus is at present in existence, but in Fig. 1 a modified form is shown having a beam connection between the indicator piston and the spring, resembling the balance-beam type of engines in use at that early period.

At about 1796, John Southern, one of the collaborators of Watt, made important improvements on this apparatus by substituting a pencil for the pointer and a piece of paper, fastened to a movable tablet, for the fixed scale. Within a stationary frame the tablet could be moved in a direction perpendicular to the pencil motion, by means of a string, against the pull of a weight. This addition made the indicator a recording instrument. In his first experiment Southern made the card carrier to move in one direction only, producing an open chart. Soon afterwards, however, he conceived the idea of connecting the card carrier with some reciprocating point on the balance-beam of the engine, thus obtaining a closed

Patented
1879.

Fig. 5. Crosby Indicator, the outstanding feature of which is the ellipse type magnifying gear used here the first time. This is one of the earliest examples preserved in the Smithsonian Institution (Washington, D. C.). Another important feature is the helical return spring in the drum. The drum can be displaced laterally and thus brought into contact with the pencil.

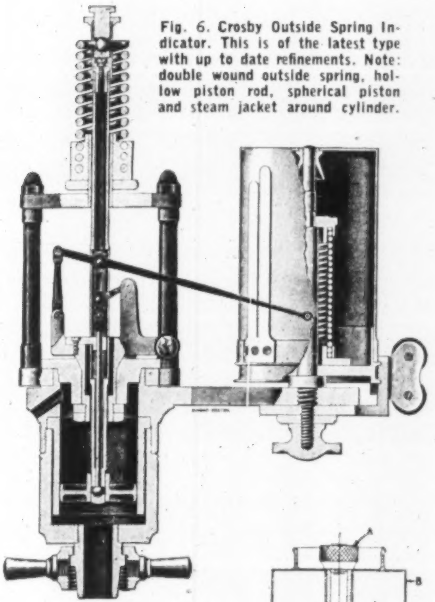


Fig. 6. Crosby Outside Spring Indicator. This is of the latest type with up to date refinements. Note: double wound outside spring, hollow piston rod, spherical piston and steam jacket around cylinder.

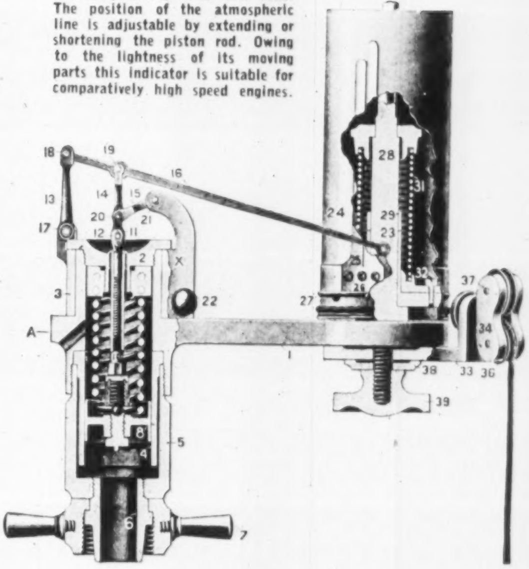

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Fig. 7. Crosby Inside Spring Indicator. Note double wound spring (in compression) with ball head. The position of the atmospheric line is adjustable by extending or shortening the piston rod. Owing to the lightness of its moving parts this indicator is suitable for comparatively high speed engines.

chart from which the work done in the engine could be determined. In this application the instrument performed the function, and contained all the essential elements of the indicator as we know it today and therefore its invention can be properly credited jointly to Watt and Southern. (Fig. 2)

Watt found the instrument extremely useful in adjusting his engines and there is evidence that the indicator diagram may have given him the inspiration for his great invention, the expansive working of steam. He endeavored to keep the instrument secret, but nevertheless, it gradually came into use and its usefulness became recognized. Around 1825-1830 John McNaught, of Scotland, began to build indicators on a small commercial scale and substituted a spring actuated drum instead of the sliding card-carrier. This improvement has greatly facilitated the handling of the instrument and represents a step towards making the instrument usable at higher speeds. (Fig. 3)

In 1862 Prof. C. B. Richards, in the United States, made another important advance in this direction, by reducing the travel of the indicator piston, and using a magnifying recording gear. (Fig. 4). This method of

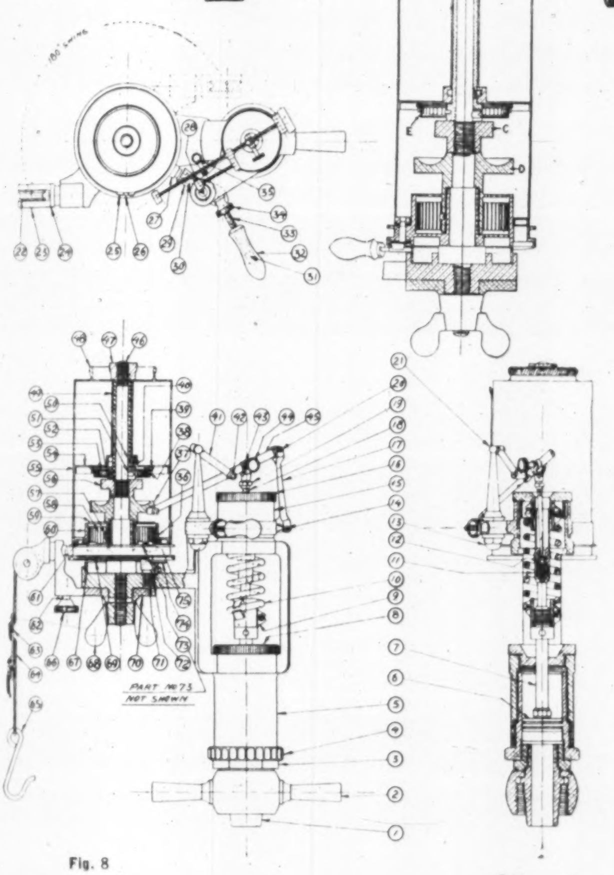
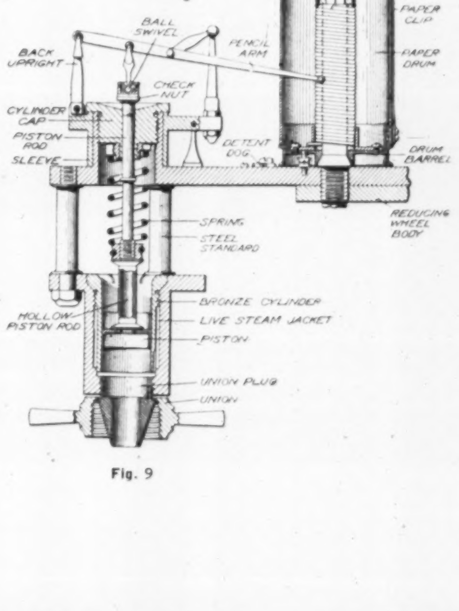

100° swing
PART No 73 NOT SHOWN

Fig. 8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REDUCING WHEEL BODY
SPRING
STEEL STANDARD
BRONZE CYLINDER
LIVE STEAM JACKET
HOLLOW PISTON ROD
PISTON
UNION PLUG
UNION

Fig. 9

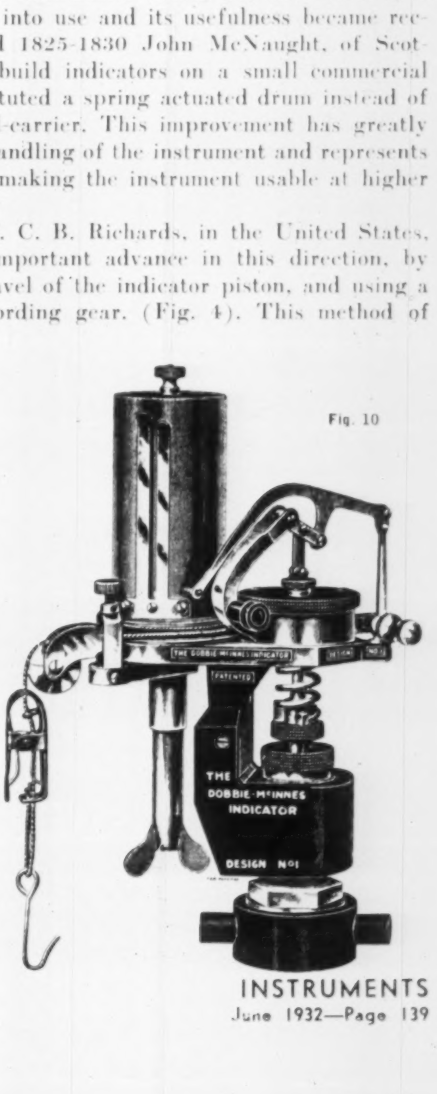

THE DOBBIE-McINNES INDICATOR
PATENTED
THE DOBBIE-McINNES INDICATOR
DESIGN No1

Fig. 10

Fig. 8. American-Thompson Indicator. Note single coil spring (in compression) removed from the hot cylinder space. Elliptic type magnifying gear. Drum furnished with volute type return spring, and a ratchet type detent device.

Fig. 9. Trill Indicator. Note hollow piston rod, single coil spring (in compression) arranged outside the indicator cylinder. Drum with helical return spring.

Fig. 10. Dobbie-MacInnes Indicator. Note single wound spring (in compression) arranged outside the indicator cylinder. Indicator body and union nut covered with heat insulating material to facilitate handling. Note unconventional magnifying gear, and clip for adjusting length of cord.

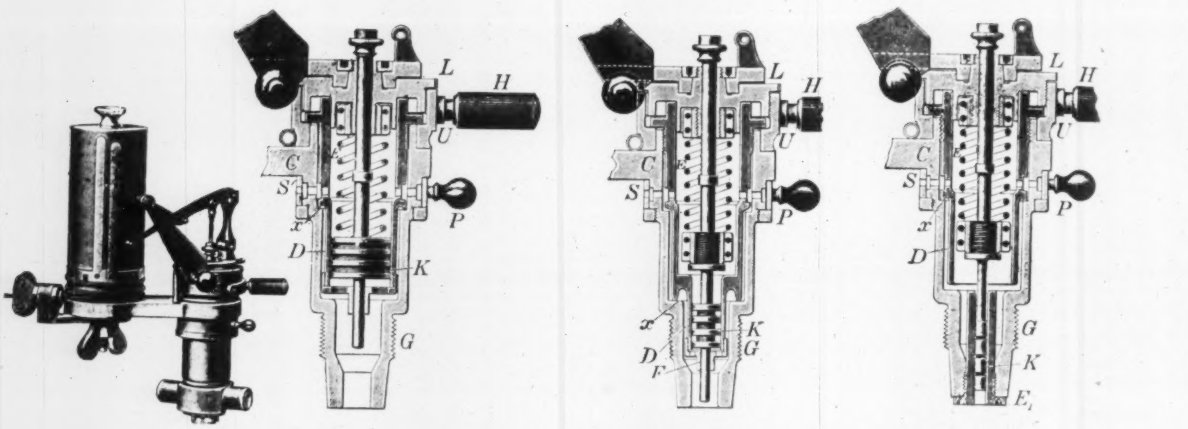


Fig. 11. Dreyer, Rosenkranz and Droop Inside Spring Indicator. Note double wound spring (in compression). Piston constructed with deep grooves and piston rod is guided both above and below the piston, in order to eliminate side thrust. The upper body is fastened to the lower part of the body by means of an interrupted screw thread like a bayonet coupling; a 60° turn of the handle H locks or unlocks the coupling and permits the removal of the upper part together with the piston and spring.

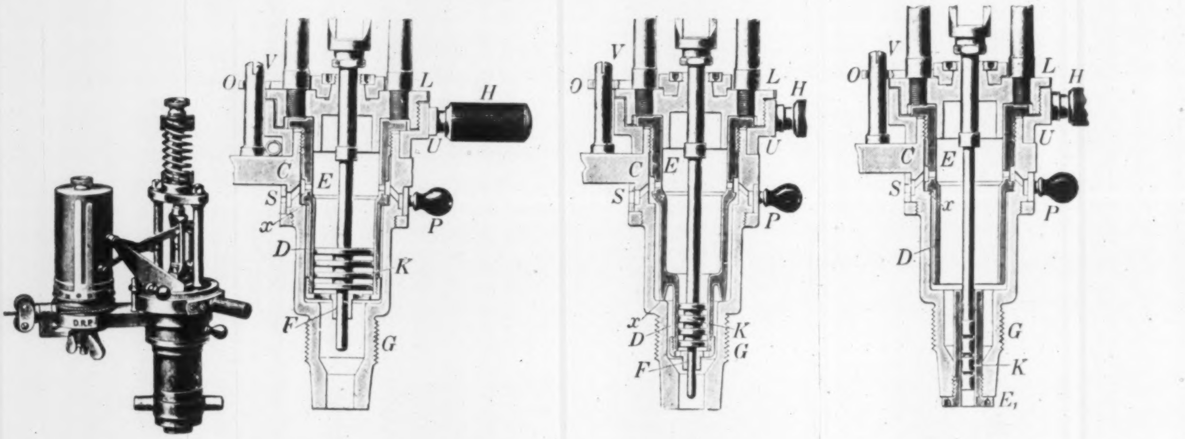


Fig. 12. Dreyer, Rosenkranz und Droop Outside Spring Indicator. Note double wound spring (in tension) fastened to a bridge piece. Forked piston rod, elliptic magnifying gear. Three different sizes of cylinder-piston sets are represented in the cuts showing the internal construction. Piston is the laminar type with wide grooves between the discs. Note guidance of piston rod both above and below the piston.

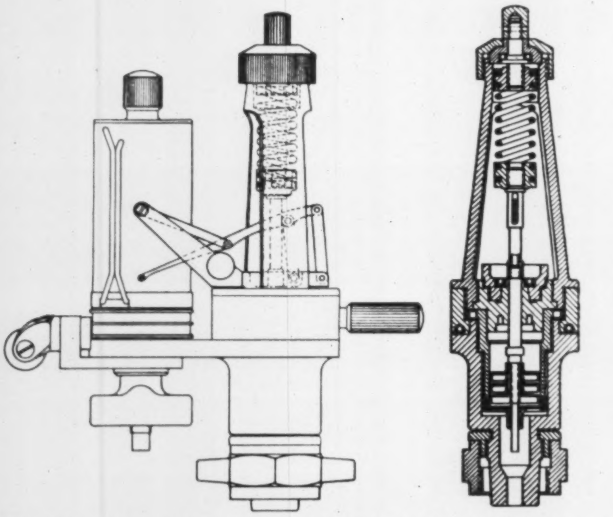


Fig. 13. Dreyer, Rosenkranz und Droop Outside Spring Indicator. Note double wound external spring (in compression) and its fastening to the upper part. Pencil motion is attached to the piston rod eccentrically in order to save space. Piston constructed of separated discs. Paper clips made of wire.

Fig. 14. Lehmann und Michels Outside Spring Indicator. Note double wound external spring, p, (in tension), Pencil movement is fixed to the piston rod by means of a clamp in order to make atmospheric line adjustable. Note forked pencil arm. The upper part (l) is rotatable on a thrust ball bearing. Cap (m) protects pencil gear from injury. Upper illustration shows a drum with detent arrangement. Note grease cup on drum axle.

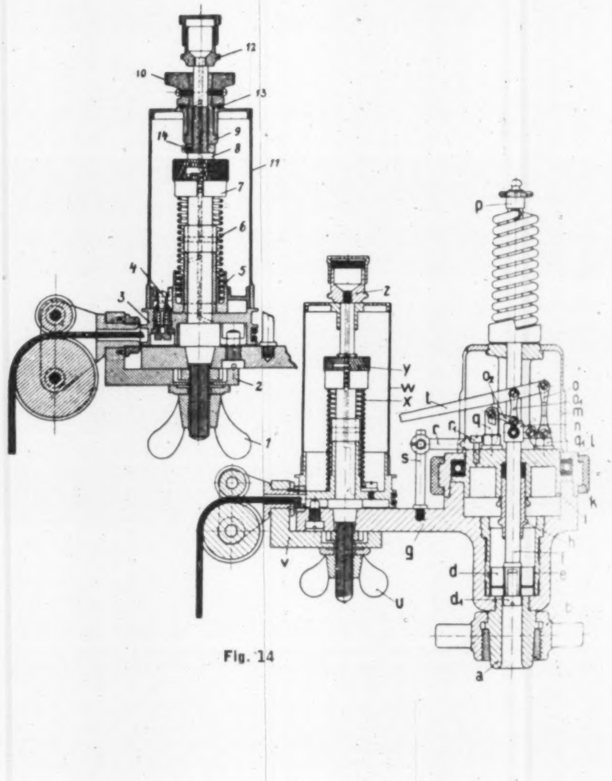


Fig. 14

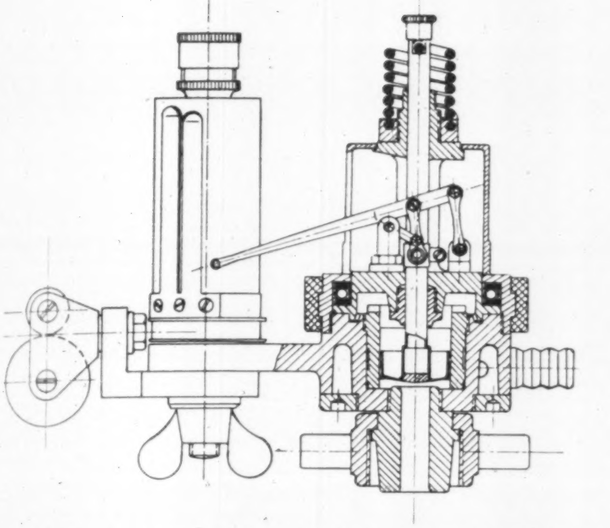


Fig. 15. Lehmann und Michels Outside Spring Indicator with Water Cooled Body, suitable for internal combustion engines. Note shortness of piston rod to reduce moving masses.

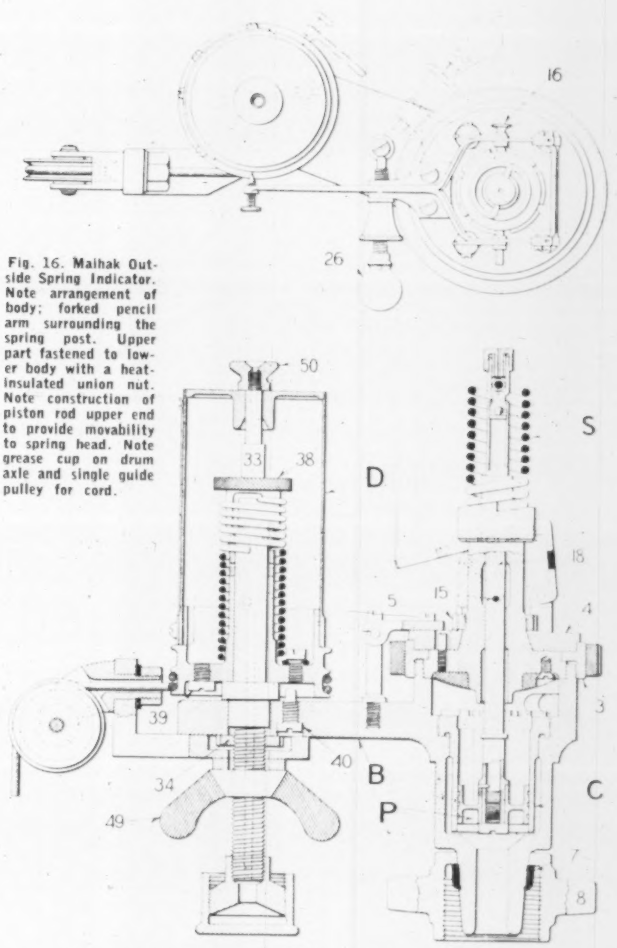


Fig. 16. Maihak Outside Spring Indicator. Note arrangement of body; forked pencil arm surrounding the spring post. Upper part fastened to lower body with a heat-insulated union nut. Note construction of piston rod upper end to provide movability to spring head. Note grease cup on drum axle and single guide pulley for cord.

construction reduces the moving masses and thus lessens the inertia errors which are brought into existence at higher rates of pressure change. However, he used a lemniscoid type of magnifying gear, which intrinsically still has considerable moving masses.

About 1879 George H. Crosby, of Massachusetts, made several important contributions to the construction of the indicator and gave it the shape and arrangement of parts which, with minor refinements, survived until today. These improvements consisted in the application of the ellipse type of magnifying gear, which can be built lighter than the lemmiscoid type; furthermore, in providing the indicator cylinder with an annular space, serving as a heat insulator and an helical type of return spring for the drum. (Fig. 5) Later, the same inventor introduced the double helical spring with a ball connection to the piston, ensuring concentricity of the load.

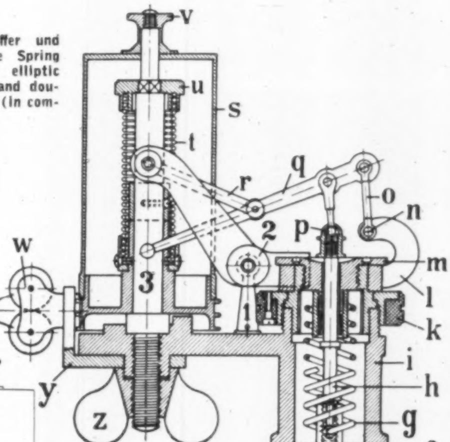


Fig. 17. Schaeffer und Budenberg Inside Spring Indicator. Note elliptic magnifying gear and double wound spring (in compression).

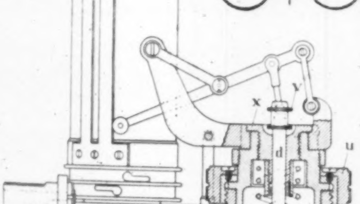
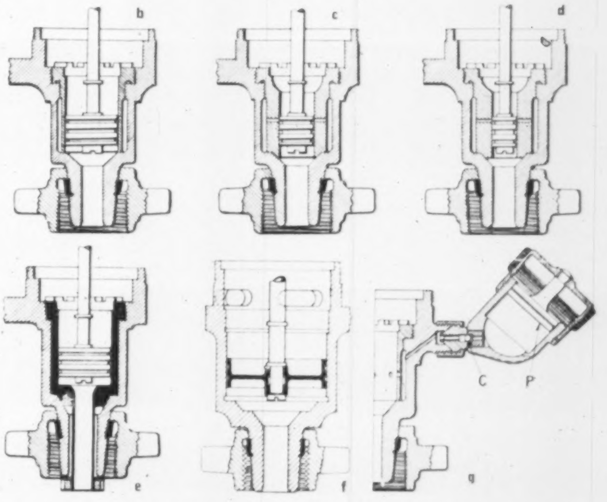


Fig. 18. Schaeffer and Budenberg Inside Spring Indicator. This is a more recent design with more refined constructional details.



b, c, d, f show cylinder-piston sets of various sizes; e shows a construction with steel bushing for use on ammonia compressors; g shows a piston lubricator especially suitable for internal combustion engines.

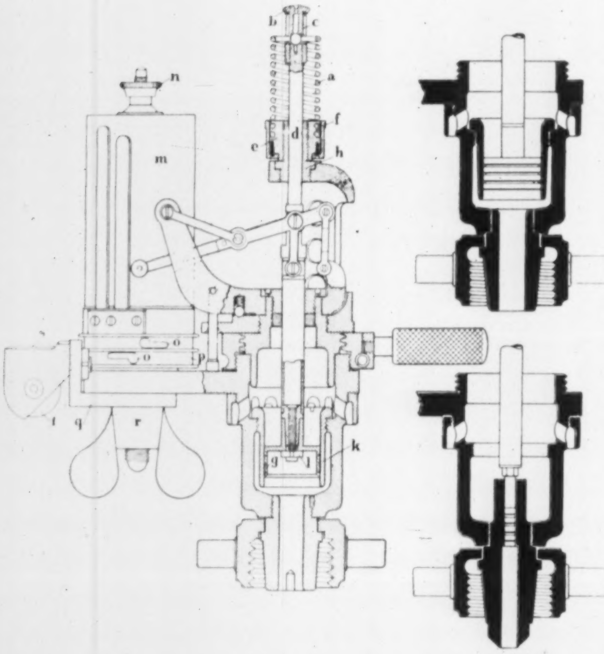


Fig. 19. Schaeffer und Budenberg Outside Spring Indicator. Note elliptic magnifying gear, quick release nut for the piston assembly upper part, also cylinder-piston sets of various sizes. Note deflecting ring for steam leakage.

With the use of higher steam pressures and temperatures it was found desirable to locate the spring outside of the cylinder. This reduces the change in the spring scale, which is otherwise occasioned by the change of temperature, and at the same time contributes to the ease of handling. Such an indicator is shown on Fig. 6.

Owing to the intrinsic scientific interest of the indicator numerous researches have been carried out on its characteristics and error sources. Outstanding among these were the early investigations of Prof. O. Reynolds and Brightmore in 1885 which were followed up by other individual scientific workers (Fliegner, Wilke, Krylow, Slaby, Rosenkranz, Staus, Holm) and research institutions, up to the present day. Ever since, the improvement of the indicator has been continued at the hands of inventors and manufacturers; of the latter the following deserve special mention:

In the United States:
  Crosby Steam Gage & Valve Company
  J. W. Thompson
  Trill Indicator Co.
In Great Britain:
  Budenberg Gauge Co.
  Dobbie McInnes, Ltd.
  Elliot Bros.
In Germany:
  Dreyer, Rosenkranz & Droop
  Lehmann & Michels
  H. Maihak
  Schaeffer & Budenberg

These efforts resulted in several refinements such as use of improved materials, heat insulation at necessary points, and lighter and stronger moving parts. With all these improvements and refinements the normal type indicator of today is a highly developed precision instrument which is convenient to operate and is sufficiently sturdy to stand comparatively rough usage. Its accuracy is sufficient for most engineering purposes, when used on engines up to 250-350 r.p.m., under conditions occurring in stationary steam, gas and oil engine practice.

With the augmentation of speed, pressure and temperature which characterizes the trend of engine development, especially that of the high speed, light weight, vehicle type, the indicating errors increase rapidly. In order to cope with these difficulties radical departures from the pencil indicator type became necessary and special instruments have been developed embodying optical, electrical and stroboscopic methods. These will be dealt with in detail later.

GENERAL ARRANGEMENT AND COMPONENT PARTS OF NORMAL TYPE INDICATOR

The rules laid down by Clerk Maxwell for the design of scientific instruments in general fully apply also to the design of the indicator and are worthy of quoting at this place. He states:

> " . . . . . Everything which is required in order to make an experiment is called apparatus. A piece of apparatus constructed specially for the performance of experiments is called an instrument.
>
> ". . . . . the fundamental principle is, that the construction of the instrument should be adapted to the use that is to be made of it, and, in particular, that the parts intended to be fixed should not be liable to become displaced; that those which ought to be movable should not stick fast; that parts which have to be observed should not be covered up or kept in the dark; and that pieces intended to have a definite form should not be disfigured by warping, straining and wearing."

The present form of the pencil indicator is the outcome of a hundred years of development. During this time many modifications were tried, only a few of which survived. In this process of evolution the weak features were eliminated and a compromise struck between what was desirable and what was technically and commercially practicable. And while the improvement is still going on, it consists mainly in utilizing engineering progress in materials and manufacturing processes, and in only slight design refinements.

As a consequence the design of the component parts of the indicator, as well as their general arrangement, has been fairly well established. The various makes of indicators differ only in constructional details, determined by their adaptation for use on steam engines, gas and oil engines, compressors and pumps.

In the following the arrangement in general and the component parts in particular of normal indicators will be considered in detail.

These can be classified into two main groups:

1) Inside spring indicators, and
2) Outside spring indicators.

The former are, generally speaking, less expensive to build and can be adapted for higher engine speeds, but have the drawback of being less convenient to handle and of having a spring constant which varies with the temperature to which the spring is subjected.

The latter, on the other hand, is more convenient to handle and has a more constant spring scale as the spring is not exposed to high temperature. But it has larger moving masses owing to the longer piston rod, and it is somewhat more expensive to build. Most manufacturers make both types.

Besides this difference in types most manufacturers make normal indicators in three or even four sizes, which give about the following diagram sizes:

Size I. 5 in. (130 mm.) long, 2¾ in. (75 mm.) high
Size II. 3½ in. (90 mm.) long, 2 in. (50 mm.) high
Size III. 2½ in. (60 mm.) long, 1¼ in. (30 mm.) high

The manufacturers usually recommend each different size for a certain engine speed limit, such as 200, 500 and 800 r.p.m. for the three above sizes respectively. These limits are, however, rather exaggerated and misleading. It would be better practice to give the magnitude of the moving mass, or the periodic time of vibration with the various springs.

The more generally used makes of indicators and their component parts are shown in the illustrations which are largely self explanatory.

A Sensitive Wood Element Hygrostat

By W. KARL LOUGHBOROUGH* and R. C. RIETZ*

THE HYGROSCOPIC property of wood that causes it to absorb or lose moisture, depending upon the relative humidity of the surrounding atmosphere, has long been used as a means of controlling relative humidity at normal indoor temperatures. With more emphasis being placed upon problems of air conditioning in recent years there is a demand for hygrostats that are both more sensitive and more reliable than those now in use. Many instruments using wood as a hygroscopic element lack the sensitivity and reliability desired at present. The purpose of this article is to indicate in one way how wood can be used in a hygrostat as a hygroscopic element and still be both sensitive and reliable.

FUNDAMENTALS

A hygrostat that uses wood or any other hygroscopic substance as its sensitive element does not actually maintain a definite value of relative humidity where temperature fluctuations exist, but varies the relative humidity in response to the temperature changes so that the moisture content of the element tends to remain the same. If wood is used as the hygroscopic element it controls the equilibrium moisture content; that is, the moisture content to which wood will eventually come when subjected to a definite temperature and relative humidity. The degree to which a control of relative humidity is gained with a wood element hygrostat is dependent upon the relationship between the temperature of the atmosphere, the relative humidity, and the equilibrium moisture content of wood. The Forest Products Laboratory has determined these relations for Sitka spruce and they are shown in Fig. 1. Other species might show some slight variations, but the general shape of the curves would be the same for all species. For practical engineering purposes these values can be considered about the same for all species of wood.

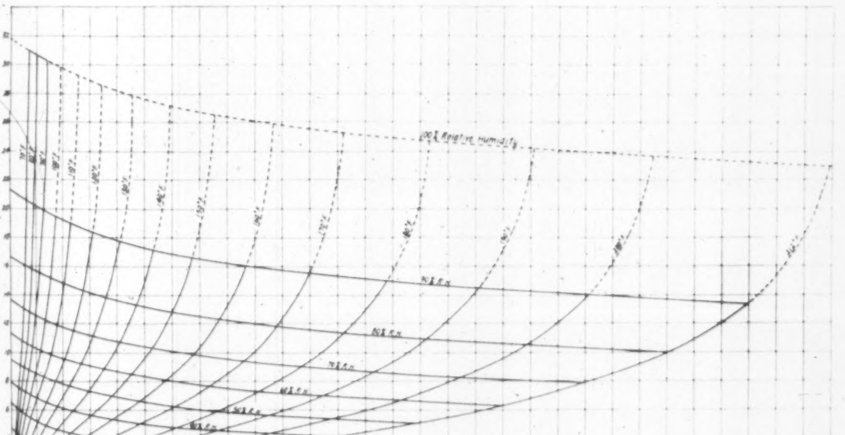
The moisture content of wood at 70° F. and 50% relative humidity, for example, is about 9%. Assume, for instance, that the dry-bulb temperature changes to 80° F. in an atmosphere being humidified under the control of a hygrostat using wood as the sensitive element: Then the relative humidity that results at this higher temperature when the element remains at 9% moisture content is about 52%. In other words, a variation in temperature of 10° at about 70° F. results in a change of 2% relative humidity. Generally this degree of control of relative humidity is sufficiently refined to meet most engineering requirements.

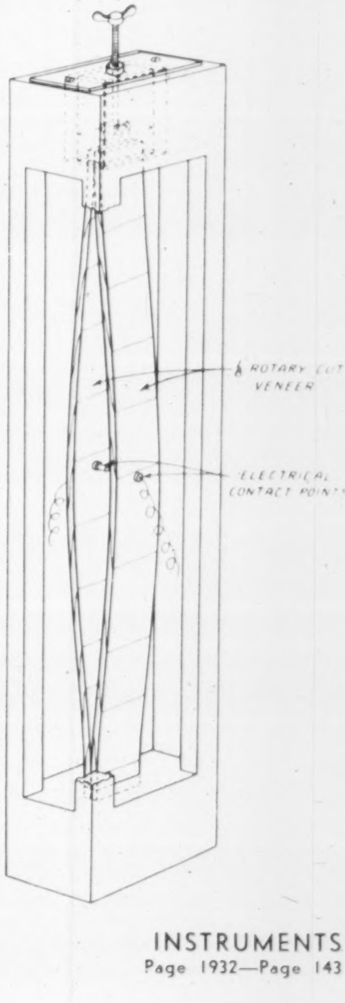
DESIGN REQUISITES

The following qualifications are considered essential in the design of any sensitive and reliable hygrostat employing wood as the hygroscopic element:

1. The wood element must have little lag in absorption or drying. This qualification involves sensitivity, which in this case is defined as the time and moisture content change required to actuate the controls. The spe-

Fig. 1. The moisture content of Sitka spruce at equilibrium with the indicated temperature, partial vapor pressure, and relative humidity





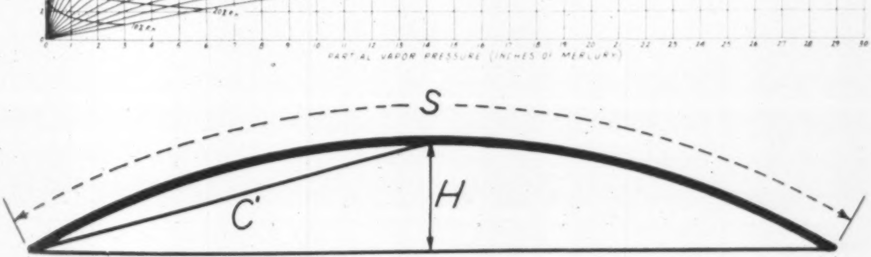


Fig. 3. Geometrical arrangement of one element of the sensitive wood element hygrostat

Fig. 2. (at right) A sensitive wood element hygrostat designed at the Forest Products Laboratory cies of wood used and the design of the wood element are the determining factors.

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*Engineer and Assistant Engineer respectively, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture. This laboratory is maintained at Madison, Wis., in coöperation with the University of Wisconsin.

2. The design of the hygroscopic wood element must be such that sufficient shrinkage and swelling is obtained to give a reasonable amount of movement with small changes in moisture content.

3. Design of the instrument must be such that little if any stress is involved in the action of the sensitive wood element when used under normal conditions of operation. The elimination of mechanisms for the magnification of the movement is desirable because of the reduction in load on the element.

FOREST PRODUCTS LABORATORY HYGROSTAT

A highly sensitive hygrostat having wood as the actuating element has recently been designed at the Forest Products Laboratory to control the equilibrium moisture content conditions in experimental kilns during the drying of lumber. The dry-bulb temperature variations in the kilns where the hygrostat is used amount to 1° or 2° F., and the equilibrium moisture content conditions within are controlled by the hygrostat to about 0.1% of moisture content. This hygrostat maintains its calibration and has possibilities of adaptation to many other moisture control problems.

The general nature of the Forest Products Laboratory hygrostat is shown in Fig. 2. The elements are 1/8 in. in thickness and 3/4 in. in width, and are made of rotary cut veneer. Elements thinner than 1/8 in. would be more sensitive to moisture changes, but so flimsy that in a brisk air movement they would tend to vibrate. Basswood was selected for the element because it responds to moisture changes readily and meets the particular requirements for stiffness. Sawing elements so that the faces are end grain increases the sensitivity but sacrifices the bending strength.

The effective length of the element described here is about 10 in. The shrinkage and swelling of the wood with small changes in moisture content is therefore sufficient to actuate the controls without further magnification other than that obtained in the geometrical arrangement of the elements. With two elements placed in a frame as shown in Fig. 2, the responsiveness of the instrument is doubled.

The geometrical arrangement of the two wood elements is such that a small change in the length of the element produces a much larger change in the rise of its arc. The relation shown in Fig. 3 between H, C′, and C for small arcs is given in the following formula:

$$S = 1/3\,(8C' - C) \qquad (1)$$

As C′ is the hypotenuse of a triangle whose other sides are H and C/2, the equation becomes:

$$S = 1/3\left(8\sqrt{\frac{C^2}{4} + H^2} - C\right) \qquad (2)$$

Solving for H, this equation shows that the change in the rise of the arc is approximately equal to the change in the arc length S, multiplied by 3/16 of the ratio of the chord C to the original rise H. For instance, with a 10 in. chord having a fixed rise of 0.1 in., a change of 0.01 in. in the arc S gives a change in the rise H of

$$\frac{3}{16} \times \frac{10}{0.1} \times 0.01 = 0.19 \text{ in.};$$

that is, a magnification of about 19 fold when the original rise is 0.1 in., or 38 fold when both elements are considered. If the original rise is say 0.5 in., and there is a change in the arc of 0.01 in., the rise becomes;

$$\frac{3}{16} \times \frac{10}{0.5} \times .01 = 0.037 \text{ in.}$$

In order to get a higher sensitivity the arc S should approach the length of the chord C, making the rise of the arc H at the controlling point very small.

This geometrical arrangement of the wood elements results in a hygrostat more sensitive and more reliable than when shrinkage and swelling are employed directly to open and close electrical contact points or an air relay. With the great magnification of the shrinkage and swelling of the elements at the control points, little change in moisture content of the elements is required to actuate the control. It is believed that the required amount of change in length of the arc to open or close the controls is obtained with changes in moisture content of the very surfaces of the element, resulting in a situation where it only requires a moisture content change of the "skin" of the wood to operate the control, whereas the moisture content of the element remains substantially the same.

RANGE

By fixing one end of the elements in a frame and making the other end adjustable as shown in Fig. 2, the instrument can be used as a controller over a wide range in equilibrium or relative humidity. For the low relative humidities the moisture content of the wood is lower and the elements are shortened, while for the higher relative humidities the elements are adjusted at a longer length. The tangential shrinkage of basswood is about 9.3% of the green dimension when it is oven dry, so that the total amount of change in length of a 10-in. element from a very high relative humidity to a very low relative humidity is about 0.9 in.

OPERATION

The operation of the arrangement is briefly as follows: Assume that the instrument is to be used in a room where steam must be admitted for humidification and that the element is electrically operated. The adjustable end of the strips or elements is moved out so that the contacts make, resulting in the opening of an electrically operated steam valve through some sort of an electrical control circuit. The relative humidity increases through the introduction of the vapor and finally the increased wood equilibrium moisture content conditions will cause the elements to swell, breaking the electrical contact, which results in the closing of the steam valve. The operation can be performed using air operated mechanisms by the use of a simple air relay and a diaphragm steam valve. Very little if any stress is introduced in the wood element by the action of the instrument, provided the supply or source of humidification is compatible with the requirements. If the rate at which the vapor is introduced so as to increase the relative humidity is too slow, there will be a tendency for the element to continue to shrink after the contact has been made, resulting in a tension stress. If this stress becomes too severe, it will cause a tension set, necessitating a readjustment of the hygrostat for it to maintain the desired humidity condition.

PRECISION

The instrument is very sensitive to slight changes in equilibrium moisture content conditions. The actual control as far as equilibrium moisture content is concerned when the dry bulb temperature varies a degree or two Fahrenheit is less than 0.1% of the moisture content, which represents a relative humidity control to within 1%. Under normal operating conditions where the source of humidification is in proper relation to the requirements, the control will not vary from its adjustment. Repeated tests with the hygrostat described here have shown that only because of some accident have the

(Continued on Page A15)

Flow Measurement and Control[*]

By M. F. BEHAR[**]

CHAPTER XXV

HEAD METERS

(Continued)

12. Pitot Tube, Centrifugal and Miscellaneous Primary Devices

(a) Some Characteristics of the Pitot Type

Pitot tube primary devices differ radically from the foregoing differential producers (Venturi, nozzle and orifice) in important respects, so that the entire "head" class of fluid meters may be said to consist of two distinct sub-classes with different characteristics and, consequently, different fields of application in the industries.

The most important distinction is apparent as one glances over all the Pitot devices on the market and the secondary devices (instruments) designed for use with them. It is that most of them are for *testing*, not for continuous measurements. (The reasons will become obvious as the basic distinctions are brought out.) Exactly the opposite holds true with regard to the foregoing three types: the Venturi is universally installed permanently, for continuous measurement; the flow nozzle and the orifice plate almost universally. A few meter manufacturers have however in recent years applied themselves to the making of Pitot meters suitable for continuous service in industrial plants, and some of these fully-developed industrial tubes are described below.

Most of the "testing" forms of Pitot tubes and their rather delicate manometers can be installed "permanently" for the purpose of obtaining continuous indications. (So can unarmored mercury-in-glass thermometers be "permanently" installed in mercury wells.)

Ed S. Smith considers that "Pitot tubes are most useful in determining flow conditions rather than as meters directly. Thus the Pitot traverse will show when a proper meter (orifice, nozzle or Venturi) will not be affected by installation conditions."

In its utilization of a distinct principle of fluid flow measurement, the Pitot type resembles the other three in that a differential head is measured, but it differs in that this head is the difference between two pressure readings one of which—the higher—is the Total or Kinetic pressure "at" *one point* in the stream, or, as the A.S.M.E. Report puts it, "the intensity of impact due to intercepting a small portion of the flow, plus the pressure on the fluid at the point under consideration." The other—the "low pressure" or "reference pressure"—may be (1) the true static pressure (difficult though it often is to obtain) or it may be (2) the static pressure minus a negative velocity effect. In case (1) the manometer indicates the velocity head; in case (2) a greater head is obtained. In case (1) the head is a reliable function of the velocity; in case (2) the effect of eddies may impair the theoretical accuracy.

The velocity head varies as the square of the velocity, as does the differential produced by the Venturi, nozzle or orifice. In general, therefore, the secondary devices for all head meters are on common ground; but there is an important distinction, namely, that the manometer or meter body of a Pitot type meter must be selected to fit the conditions of flow as they exist in the pipe or duct, whereas with the other types the form of the primary device can be selected to suit a particular form of instrument or meter body and some of the characteristics of the primary device can even be altered to suit the range of the manometer. Thanks to the development during the past few years of several improved types of manometers and micromanometers covering all ranges of

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[*] Part VI of ***The Manual of Instrumentation.***

[**] Engineering Editor.

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differential heads, it is an easier matter to adapt the manometer to the tube, making it a meter unit comparable in usefulness to the other types of indicating instruments. Recorders are fewer, however, as compared to the many successful Venturi, nozzle and orifice recording meters.

Pitot tube elements are inexpensive. They offer little obstruction and cause no appreciable loss of head except in small pipes (in which they should not be used).

The outstanding distinction, of course, is that since a Pitot tube gives only the velocity of a narrow filament of the stream, knowledge of the velocity curve is necessary. It should be recognized that the distribution of the velocity in a pipe is delicately balanced. It is low along the side walls and has a roughly elliptical peak at the mid-diameter. For example, in a 10-in. pipe, the peak will have practically a flat front for two or three inches. With usual turbulent hydraulic flow this peak is continually changing slightly. It is surprising how much straight pipe is required following a bend, for example, in order to straighten out the flow and bring the velocity traverse back to normal, that is, symmetrical all around the axis.

One has the choice, for permanent industrial installations, of installing the tube with the impact opening at the central maximum velocity or at some arbitrary point within the pipe area, bearing in mind these conditions.

The *averaging Pitot* is not a particular form, but a Pitot device of which the impact opening is located at a point where the filament velocity is equal to the true mean speed of the fluid. In a straight conduit of exactly circular cross section with smooth walls and in which the flow is truly parallel so that the velocity curve is parabolic except near the wall, the velocity of any filament in an elementary concentric annulus the diameter of which is 0.7 *D* will generally correspond to the mean speed closely enough for metering purposes. If the velocity curve is a semi-ellipse the annulus diameter is approximately 0.75 *D*. An impact hole intercepting a filament from 0.125 *D* to 0.15 *D* away from the sidewall, therefore, may be used for the high-pressure side of an averaging Pitot. This method, formerly in vogue not only for engineering tests but for continuous metering, has proved to be less reliable than theory predicts. The reason seems to be uncertainty of velocity distribution in any given case. The curve is hardly an ideal semi-ellipse: it assumes an infinite variety of shapes from those for smooth pipe to those for rough pipe; from those for streamline flow with low Reynolds number to those for very turbulent flow with very high Reynolds number. It being recognized nowadays that the radius of mean velocity varies not only as anticipated with pipe diameter roughness and fluid velocity but too often unaccountably, and that the annulus of mean velocity is neither concentric nor a true circle, the averaging Pitot is no longer used for practical, continuous *metering*. (It is still found occasionally in steam sampler calorimetric work but this and other test applications fall outside the province of Part Six.)

For cases where it is desired to use a *fixed* Pitot tube as an industrial fluid metering primary device, the *central Pitot* may fairly be considered a true quantity-rate meter since it gives a velocity which, when multiplied by the proper pipe factor and the pipe sectional area, determines the true quantity-rate. (After all, with any other quantity-rate meter, it is mainly a question of taking the square root of the differential, an area and some factor.) The pipe factor or pipe coefficient is determined by traverse, except (1) in cases where a positive meter (or other "standard") can be installed temporarily for calibrating the Pitot meter; (2) in cases where accuracy is not demanded and any guess between the normal limits of 0.55 and 0.88 will do for the pipe coefficient; (3) in cases where flow distribution is known to be normal so that if the value of 0.83 is taken for the pipe factor, the error of Pitot meter with a properly rated tube will probably not exceed ± 1 percent of the manometer reading at mid-range. There are other exceptions, but the mere statement of these cases shows the desirability of making traverses.

In the case of perfect streamline flow the mean velocity is exactly 0.5 the maximum velocity, but this ideal condition is never met with.

Before deciding to use any form of Pitot device for continuous metering it must be borne in mind also that the pipe coefficient seldom holds over a wide range of velocities. This is not an insuperable drawback, because for accurate metering one can make traverses at various rates of flow and plot the values of the pipe factor against rates of flow or against center-line velocities. When this is done, the result is a curve which departs from the square-root curve. If the departure is considerable, a secondary device which extracts the square root of the differential (mechanically or otherwise) may hardly be expected to give exact readings or produce accurate records over the entire range.

When full-range accuracy is not required—that is, when the metered fluid flows at a fairly steady rate, the error due to varying pipe coefficient can be disregarded.

Another reason for using the central Pitot rather than the "averaging" is that the former will either read correctly or read low. It should be located at the point of maximum velocity and then if the distribution curve later wavers for any reason, the result is generally a lower differential. It is true that some change in the upstream conditions could so alter the shape of the curve as to give a higher peak for the same curve area (rate of flow), but this seldom happens in practice. The only case that comes to the author's mind as being at all likely to happen is the *removal* of a disturbance. The disturbance might have produced a turbulent kind of flow with a flat-front velocity distribution and a small difference between center line velocity and mean speed, so that its removal *after* the pipe coefficient was determined would increase the center line velocity for the same rate of flow and make the meter read high regardless of the design of the Pitot device. Or else, the disturbance might have produced a swirling kind of flow with centrifugal effects causing a fictitiously high sidewall static (fictitiously low Pitot head) and its removal would make an elementary or single-opening Pitot type meter read *correctly instead of low*. Again, the disturbance might have produced a velocity distribution curve with off-center peak and its removal *after* determining the pipe coefficient for a geometrically centered impact opening would make the meter read high.

Lastly, we may state a distinction between the Pitot and the other three types which is of prime importance in scientific work and of interest in practical metering: A correctly designed and properly constructed Pitot tube can be used as a "primary" device in the sense that it can be used without calibration as a Standard for measuring the velocity of a flowing medium. In other words an ideal Pitot device does not produce any differential but merely takes off the velocity head—the exact difference between Total and Static pressures.

(b) Reducing Errors in Measurement of True Velocity Head

There usually is little difficulty in obtaining the true Total Pressure with an opening normal to the direction of flow, and the impact openings of commercial Pitot devices give little trouble, except when metering sewage or dirty fluids.

But it is an altogether different matter to obtain the true *static* pressure at a given point in the midst of a body of fluid in motion. Sidewall openings are likely to give erroneous readings by reason of burrs, rivets or roughness of conduit surface nearby, and except when the fluid flow is perfectly parallel and other conditions favorable, sidewall static taps are not entirely reliable. Sidewall static taps should be carefully inspected by a competent person in every case. In measuring highly turbulent flow, the sidewall static is sometimes chosen as the lesser of two evils because it gives the static pressure with less uncertainty than some trailing taps. Several commercial designs get around the difficulty by making use of large negative velocity effects and thus providing a "reference pressure" correspondingly lower than the true Static Pressure, and these are eminently practical for industrial metering purposes, provided only that an initial calibration be made. All such devices *must* be calibrated because the differential which they utilize is not the true velocity head.

In such Pitot tubes as the well-known "A.B.C.," the side holes are located with smooth tubing for at least 8 tube diameters upstream and downstream and therefore can be relied upon to give the true static pressure in the midst of a body of fluid in parallel flow when the tube itself is correctly aligned. But, again, it is a much more difficult problem to obtain the true static pressure at a particular point in the midst of a *turbulent* fluid stream. This problem was solved in 1926 by C. J. Fechheimer who devised the instrument illustrated herewith. Before his work, it had been believed rather widely that a tube with very small holes, uniformly distributed all around, should read substantially correctly, as for some holes the velocity head adds to, and for others it subtracts from, the static pressure, the net result in theory being negligible influence of velocity head. It was recognized, however, even before Fechheimer's work, that such a device was not satisfactory, and it appears that the reading is low by about 50 percent of the velocity head.

It also had been believed that the axis of a static tube should be parallel to the axis of the conduit, and this belief was bolstered by countless observations that errors increased with (always small) angles of "yaw." Fechheimer increased the angle to 90 deg., positioning his tube *squarely across the stream*, and the errors vanished.*

---

*Positioning a tube across the stream was of course not original with Fechheimer: Spitzglass had designed, investigated and reported on such forms.

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ELECTRICAL ENGINEER: Graduate Charlottenburg Technische Hochschule; 8 years research engineer with chemical company; 4 years steel plant electrical engineer; can read German, French, Spanish and Italian. J-6.

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PYROMETER MAN: 8 years experience; expert electrician and gage (hydraulic, pressure, vacuum, etc.) service man; 3 years instrument laboratory; education equivalent two years of engineering college. J-9.

INSTRUMENT ENGINEER: Graduate Engineering College. Charge of instrument department in large industrial plant for 2½ years. J-10.

RADIO OPERATOR: Graduate Dodge Institute, 1917. Commercial license either broadcast or telegraph. J-12.

INSTRUMENT SALESMAN: Graduate M.E., 4 years control instruments, 2 years power plant specialties, 4 years manufacturing experience, in shop. Now N. Y. District Mgr. large rolling mill. J-13.

PHYSICIST: Ph.D. 1927. Experienced in electric and magnetic measurements, testing and research. J-14.

PRECISION INSTRUMENT MAKER: 28 years experience on scientific and geophysical instruments. J-15.

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ELECTRICAL METER and INSTRUMENT MAN: Technical graduate, 8 years in instrument laboratory of electrical manufacturing company. J-17.

INSTRUMENT ENGINEER: 2 years university, 5 years public utility, 2 years sales and service large recording and controlling instrument manufacturer. J-18.

INSTRUMENT MAKER: Engineering and Drafting instruments, 20 years shop experience, Master Degree Guild of Nuremburg. J-19.

ELECTRICAL ENGINEER: Graduate Purdue University. Experience with Telephone and Telegraph circuits, industrial control methods and equipment, and electrical instrument testing and maintenance. J-20.

AIRCRAFT INSTRUMENT MAINTENANCE ENGINEER: Formerly Service Engineer for largest manufacturer of aircraft instruments. Especially familiar with airplane instrument problems. J-21.

Another widespread belief was that the plane of a static hole must be parallel to the direction of flow. E. Ower goes even further and declares in his *Measurement of Air Flow* that "in the design of a *tube* to measure static pressure . . . it is essential to observe the condition . . . that the flow past the static orifice must be, as far as possible,the same, both in speed and direction, as it was in the free stream undisturbed by the presence of the instrument." Observance of this condition may be conducive to good results in streamline flow. Although air flow is highly turbulent in the great majority of pipes and ducts met with in metering practice, still the mean flow is in steady "dynamic" streamlines. The plane of the chord of each static hole in the approved form of Fechheimer tube makes an angle of 50.75 deg. with the direction of the free stream.

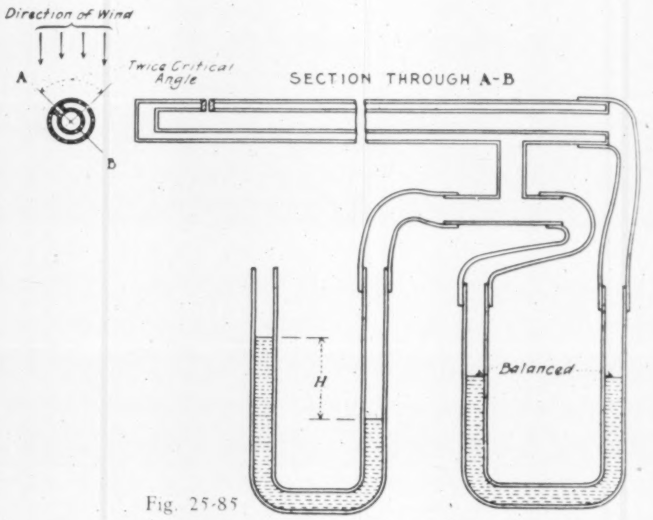

Fig. 25-85

Finally, there was the belief that—as Ower puts it—"any device for measuring static pressure will give erroneous results if it deflects the air to any appreciable extent." The Fechheimer tube deflects the flowing medium.

Fechheimer's device consists of two small brass tubes (as shown in principle in Fig. 25-85), the diameter of the outer one being ¼ in., and of the inner [illegible] in. The inner tube communcates with the outer surface through a small hole, and the annular space between the two tubes communicates with the outer surface by means of another small hole displaced from the first hole circumferentially by double the critical angle. The inner and outer tubes are then connected independently to the two sides of a U-tube or other manometer, and when the device is in a moving stream, it is *turned on its axis until the U-tube reads zero.* Then the stream bisects the double-angle, so that if one side of the U-tube is then opened to the atmosphere, the static pressure only will be read.

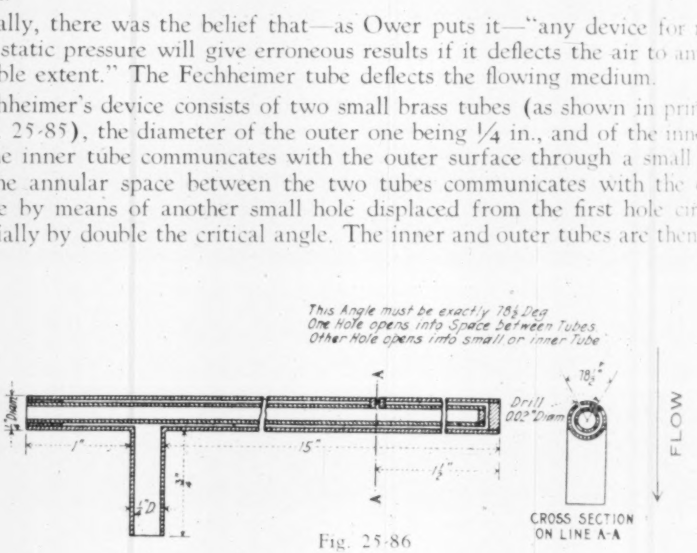
This Angle must be exactly 78½ Deg
One Hole opens into Space between Tubes
Other Hole opens into small or inner Tube
¼" Diam
1"
15"
1½"
¼"D
Drill .002" Diam
78½°
FLOW
CROSS SECTION ON LINE A-A

Fig. 25-86

There is, of course, the possibility that the tube be turned 180 deg. from the impact side, and then the reading will be too low. To overcome this difficulty, it has been found advisable to use two manometers, one for balancing and one for reading the static pressure, a suitable T-connection being used on one side for connecting to the second manometer. Then the manometer used for balancing would read zero for the two positions of the pressure tube, which are 180 deg. apart. The second manometer, which reads the pressure, would then record a high and a low value for the two balanced positions. The high value is the correct static pressure. (If the pressures are below atmosphere, the higher reading is the one that is numerically smaller.)

Fig. 25-86 shows the construction of a typical Fechheimer tube. He reports finding that scratches and slight departures from a true cylindrical surface on the outside affect the results. The tube should be ground, so as to make it a substantially perfect cylinder. It was found also that the location of the hole axially, or the use of a spherical instead of a square end, had practically no influence upon the critical angle. Tests were also made in a duct 1 1/16 in. in diameter and the results showed that the tube disturbed the flow so much that the static pressures, ahead and behind the cylinder, were considerably different. The device is not recommended, therefore, for the measurement of static pressures in small ducts.

When a stream is highly turbulent, it is difficult to state the "static pressure." There are probable interchanges from static to velocity head, and vice versa, and it is therefore impossible absolutely to *define* static pressure. The best that can be done is to standardize upon some method of measurement. It is believed that measurements with Fechheimer tubes may well serve for such basis, at least until the character of turbulent flow is understood better than it is at present.

H. L. Dryden of the Bureau of Standard, commenting on the critical angle of 78.5 deg., states that

> The angle between the two positions on the cylinder at which the pressure equals the static pressure varies with the size of the cylinder, with the distance from the end of the cylinder, and with the wind speed. The maximum included angle ever observed is 84 deg. . . . The lowest values obtained for cylinders not exceeding 1 in., in diameter are about 74 deg. . . . Now the error in static pressure produced by an error of 5 deg. in the location of the holes is about 8 percent of the velocity pressure, so that a tube with an angle between the holes of 80 deg. should not give an error greater than 8 per cent of the velocity pressure. For particular purposes a judicious selection of the angle would reduce the error. For example, if the stream were known to be nearly perpendicular to the cylinder, the use of holes 0.02 in. in diameter, 1 in. from the end of a 3/16-in. cylinder, with an angle between the holes of 82 deg., would make the errors less than 5 per cent. . . . The general variations may be summarized as follows:
>
> (a) The angle is larger for holes in the center of a cylinder running completely across the stream than for holes near the end of a cylinder extending only to the center of the stream.
>
> (b) The angle decreases with increasing diameter of the cylinder, other things remaining the same.

(c) Traverses and Determination of Pipe Factor

Since the quantity-rate is the product of conduit cross-sectional area and of mean velocity, it follows that the cross-sectional area of the conduit must first of all be known. It is not amiss, therefore, to mention the frequently considerable discrepancies between nominal diameter and actual internal diameter of commercial pipe and tube.

Whether the traverse is to be made with an impact tube (and separate static take-off) or with a combined tube, the device selected should be so constructed that its impact opening (or both) can be conveniently and accurately located at any place from the geometric center to near the sidewall (see below for distances). It should be long enough—and with a few inches to spare to facilitate manipulation. It should either have a non-turning stem, to assure that the impact opening will always face straight upstream, or at the outer end some sort of a guide vane or direction indicator long enough to assure correct head alignment. It should be provided with a linear scale-and-pointer arrangement to show the exact distance of the impact opening from the sidewall. Some commercial Pitot tubes are furnished with graduated stems but this is not a necessity, and some engineers prefer to take a blank strip of brass (or an ordinary lath), graduate it especially for the traverse with only the reference marks corresponding to the several pre-determined distances, and fasten it alongside the stem.

Number of Observations. Since the actual curves of velocity distribution are never perfect conic sections, the number of observations for an accurate determination of the pipe factor should be such that the uncertainty in plotting these actual curves can be reduced to an extent representing, say, one-half percent of the subtended area. Greater accuracy is unnecessary unless the traverses are made with a "Standard" tube connected to a calibrated manometer, as in scientific test work when the precision of the method must match the precision of the instruments.

The majority of traverses in industrial work are made with tubes that are far from being primary standards; micromanometers and other precision differential gages are seldom used; it is difficult to maintain a perfectly steady flow; readings are not and cannot be made to four significant figures. Hence the "ten point" method, which has a theoretical possible error of 0.3 percent, amply serves the purpose for all conduits of circular cross-section, up to medium size.

CHEMIST: Graduate Hunter College 1918. Spent twelve years working out various chemical processes in the laboratory and demonstrating them from a practical standpoint in paper mills. Work in the laboratory has included water analyses, some bacteriological work, fibre examination and testing of various materials. J-22.

ADVERTISING MANAGER: Also assistant sales manager of flow meter manufacturing company; available March 1. M.I.T. graduate Mechanical Engineer with 10 years shop, engineering, advertising and sales experience. J-23.

PHYSICIST: 2 years experience in research with particular training in atomics and electronics. Have held two fellowships. J-24.

COMMUNICATION ENGINEER: 10 years practical experience in installation, operation and maintenance of high frequency transmitters and receivers, also land line practice. Knowledge of Spanish. J-25.

ELECTRICAL ENGINEER: Experience with electric meter manufacturer and with an electrical testing laboratory. Master's degree in electrical engineering. J-26.

SALES ENGINEER: Sales promotion work on scientific instruments, industrial control, etc. Three years experience with manufacturer of scientific instruments and three years experience with manufacturer of automatic regulating devices. Graduate of University of Chicago. J-27.

ELECTRICAL ENGINEER: Graduate of University of Illinois with experience in development of control apparatus desires connection in research, design, or development of instruments or control apparatus. J-28.

SALES ENGINEER: B.S. degree, 1931, and graduate work in Physics and Chemistry, sales experience. Desires permanent connection with instrument manufacturer with opportunity to enter sales department. J-29.

MECHANICAL AND CHEMICAL ENGINEER: College graduate, experienced in general machine shop work, drafting. Three years as second assistant engineer in merchant marine. J-30.

SALES ENGINEER: Experienced in shop, service and sales. Interested in handling unit heat, ventilation and air conditioning apparatus. Licensed professional engineer. J-31.

METER SPECIALIST: 20 years experience with utilities and manufacturers. Meter, distribution and sales department. College education. J-32.

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RESEARCH ENGINEER: Technical Director, Chemical Engineer, Research Chemist, expert in paper, oils, dyes, chemicals, fuels, augment and improve production, cut costs, sales service, patents, literary work, 6 languages. Trained Harvard and abroad. J-34.

MECHANICAL ENGINEER: 11 years experience in design, construction, sale, and servicing of power plant and industrial metering, regulating and control equipment. J-35.

AUTOMATIC MACHINE DESIGNER: 15 years designing experience on automatic machines including 5 years on boiler instruments, testing instruments and telegraph instruments. J-36.

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MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

141 Immersion Heater. Bulletin No. 270 illustrates one type of Falcon bare electric immersion heating units suitable for large tanks used in connection with asphalt, tar, compound, varnish, oil and similar viscous materials which are electrical insulators. H. O. Swoboda, Inc., 3530 Forbes Street, Pittsburgh, Pa.

142 Microtome. Bulletin T-10 describes a rotary microtome No. 818 and other microtomes. Microtome No. 818 meets the demand for a dependable instrument of precision. Spencer Lens Company, Buffalo, N. Y.

143 Watches. A leaflet dated January, 1931, describes stop watches for technical and scientific purposes. Aristo Import Co., Inc., 12 John Street, New York.

144 Microscopes. Booklet M-52 describes and illustrates microscopes for general laboratory use. Spencer Lens Company, Buffalo, N. Y.

145 Testing Machines. Pamphlets describing Type MPS-4, for testing long specimens, in tension, compression, transverse and bending, this machine being made in capacities of 50,000 to 300,000 lbs. Also Type MP-10 of 10,000 and 20,000 lbs. capacity. This type of machine for either hand or motor drive. Steel City Testing Laboratory, 8843 Livernois Ave., Detroit, Mich.

146 Resistors and Rheostats. Circular 507 describes vitrohm resistors and rheostats for radio. Ward Leonard Electric Company, Mount Vernon, N. Y.

147 Field Rheostats. Bulletin 60 A illustrates field rheostats which are designed for a straight line relation between the steps of the rheostat and the field current. Ward Leonard Electric Company, Mount Vernon, N. Y.

148 Regulators. Bulletin 1101 describes speed regulators of the ventilated type. Bulletin 1102 describes speed regulators of the totally enclosed type. Ward Leonard Electric Company, Mount Vernon, N. Y.

149 Bakelite Review. The April 1932 issue of this publication has as one of its feature articles, "Waterproofing the Band-Aid with Bakelite Resinoid." Bakelite Corporation, 247 Park Avenue, N. Y.

150 Detector Equipment. Bulletin 56 describes rail testing equipment for detecting internal defects in used rails before re-laying. Bulletin No. 57 shows how the Sperry Detector Car can locate hidden rail defects. Sperry Products, Inc., Manhattan Bridge Plaza, Brooklyn, N. Y.

151 Testing Machines and Instruments. Catalog 50, Part H gives a complete description of miscellaneous testing machines for efficiency of cutting or abrasion tools; alternate stress in materials, impact, torsion, cold bend, hardness, oil and bearing metal, and for other special purposes. Also dynamometers and miscellaneous instruments. Price $1.00. Tinius Olsen Testing Machine Company, 500 North Twelfth St., Philadelphia, Pa.

152 Lathe. A booklet in two colors, illustrating and describing the small shop lathe known as the 8-inch Junior. South Bend Lathe Works, 426 E. Madison St., South Bend, Indiana.

153 Protective Cements & Compounds. Catalogue No. 32 containing instructive information on industrial assembling, insulating, acid-proofing, etc. Technical Products Company, Sharpsburg Sta., Pittsburgh, Pa.

154 Microphone. A circular describing a crystal microphone, type 4202 which operates on the piezo-electric principle. It does not require button current, or polarizing voltage. The Brush Development Co., 3715 Euclid Ave., Cleveland, Ohio.

The twenty-point method gives added assurance in the case of very large conduits (and is then employed because the additional time and expense required are often trifling in comparison with that of the preparations for the traverses).

It is advisable to make *two* ten-point traverses, along mutually perpendicular diameters. Fig. 25-87 (which is "Plate B" of the Standard Test Code for Disc and Propeller Fans, Centrifugal Fans and Blowers adopted by the National Association of Fan Manufacturers and the American Society of Heating and Ventilating Engineers) shows the method. Where poor upstream conditions exist it is wise to take two extra traverses on the 45-deg. bisectors as well.

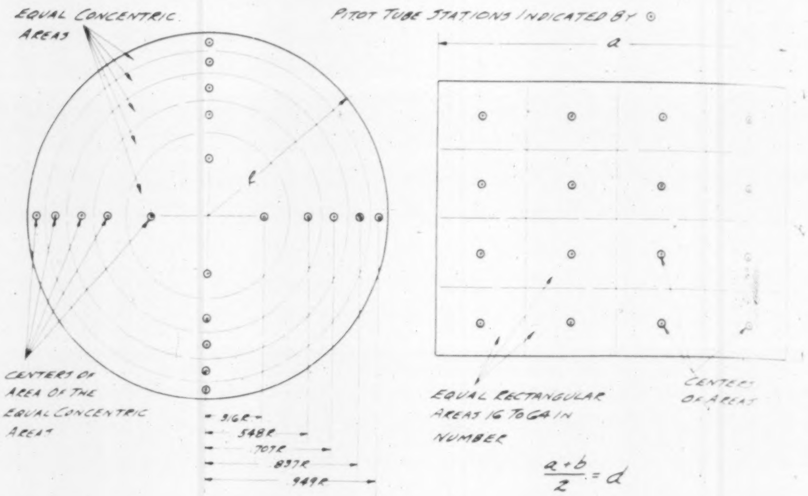
EQUAL CONCENTRIC AREAS
PITOT TUBE STATIONS INDICATED BY ⊙
a
r
CENTERS OF AREA OF THE EQUAL CONCENTRIC AREAS
.316R
.548R
.707R
.837R
.949R
EQUAL RECTANGULAR AREAS 16 TO 64 IN NUMBER
CENTERS OF AREAS
$\frac{a+b}{2} = d$

Fig. 25-87

For twenty points along one diameter (ten instead of five equal concentric areas) the ten distances from center are as follows:

Zone	*Radius*	*Zone*	*Radius*
1	0.2237*R*	6	0.742*R*
2	0.3875*R*	7	0.807*R*
3	0.500*R*	8	0.866*R*
4	0.592*R*	9	0.922*R*
5	0.671*R*	10	0.975*R*

For small pipes, of course, the number of points has to be reduced in order to make it possible for the axis of the tube to be positioned at the pre-determined point closest to the sidewall. For six points along one diameter, the three points along one radius will be 0.408*R*, 0.704*R* and 0.912*R*.

A combined Pitot device should not be closer to the sidewall than its own head diameter, in order to prevent errors in the static side-hole readings. Special combined tubes of small head dimensions are made, but they require individual calibration because of the impracticability of attaining geometric conformity with the several accepted Standards that have a coefficient of unity or close to 1.00. On the whole, it is advisable and sometimes necessary to traverse a small pipe with a suitably small kinetic tube and take off the static pressure at the sidewall with an independent sidewall tap.

Computing Mean Velocity. Having obtained the velocity head at a number of points each of which is the center of an equal-area zone, extract the square root of each and divide the sum of the square roots by the number of equal areas. This gives the square root of the mean velocity head.

Computing Pipe Factor. In addition to the readings at the pre-determined points of the traverses for mean velocity, one more is needed, either (1) at the geometric center or (2) at the point of maximum velocity ascertained from the curve obtained by traversing. This reading should of course be taken at the same rate of flow that is maintained for the traverse, and it is expressed in the same units (inches of water, etc.) but it is not used in the computation of mean velocity. The square root of this reading is extracted, and the pipe coefficient or factor, then, is the ratio of this square root to that of the mean velocity head. Therefore the pipe factor is the ratio of metered *velocity* to mean velocity —which simplifies practical metering. As stated, its usual value is around 0.83 for parallel flow of usual turbulence in hydraulic work and it is likely to vary considerably.

Rectangular Ducts. Fig. 25-87 shows also the equal-area method for ducts of rectangular cross-section. The computations are the same as given in the foregoing paragraphs.

(d) Rating and Calibration

That the terms "rating" and "calibration" are used indifferently by many writers in the technical journals need not concern industrial users except when a tube is to be used over a wide range of velocities. The result of a rating is one numerical value; the result of a complete calibration is a set of values which may be presented graphically in the form of a calibration curve as with all measuring instruments applied to variables—in this case the values of the tube coefficient being plotted against velocities.

The purpose of a rating is to determine the coefficient C in the equation $v = C\sqrt{2gh}$. (An ideal Pitot device, reading the exact velocity head, would have a coefficient of 1.00 at all velocities.) This coefficient is the *design coefficient,* determined by the manufacturer and furnished to the user on request. It is of little use to the purchaser of a complete meter, unless the Pitot tube of the meter is to be used separately. Pitot tubes are generally rated nowadays by being placed in the throat of a Venturi or flow nozzle. Since small turbulence exists there, an academic question arises as to whether or not this same rating holds when the Pitot tube is used to measure turbulent flow in a pipe. However, experience has shown that quantity-rates of flow can be determined in this way within one percent in the hands of an experienced and skilled observer. Formerly Pitot tubes were rated by moving them through still water with a rotating swing arm or traveling carriage. The rating was equally acceptable but the nozzle method proved more convenient. The calibrated-nozzle method of S. A. Moss (1916 *Transactions* of A.S.M.E.) is useful not only for determining quantity-rates but for determining Pitot tube coefficients at known velocities of a known flowing medium. See also Bureau of Standards Research papers RP49 and RP303 in which Dr. E. Buckingham has given this matter unparalleled treatment.

(e) Forms of Pitot Devices

It is convenient to start, as does the A.S.M.E. Report, by dividing all of of the many forms of Pitot devices into (1) the elementary forms, in which the static head is taken at some fixed point, usually the wall of the conduit; the static tube being entirely separate from and independent of the kinetic tube; and (2) the combined forms, in which the static and kinetic openings are fixed in relation to each other, with both tubes mounted in the same casing and inserted in the flow as a single unit.

From the viewpoint of the practical man considering the adoption of a Pitot type fluid meter for industrial use, the two most important questions are (A) whether a particular form of Pitot device being considered can be installed conveniently and without excessive cost or lengthy shut-down; and (B) whether such particular form will give sufficiently accurate results after installation under the service conditions as they actually exist.

(A) Ease of installation through a small hole in the pipe wall is the obvious answer to the first question. This is possible with many forms designed for industrial service, some of which are illustrated. Moreover, some commercial forms are made for installation without interruption of service; it is possible to install a corporation cock in a line under pressure and Pitot devices are manufactured with this convenience in view. Note, however, that the constancy of the value of the tube coefficient over a wide range of velocities is sacrificed in the majority of such forms, and the highest attainable accuracy is subordinated to practical convenience in some designs. (Note also that not one of the combined forms designed for highest attainable accuracy can be installed conveniently and inexpensively and without interruption of service. These approved precision forms are all of the "bent" design.)

(B) As to the criterion of accuracy under prevailing service conditions: Some of these conditions—those of *flow*—have been discussed above. Another, of prime importance in practical metering, is *vibration.* For industrial metering, as distinguished from test work, all forms of Pitot devices can be divided into (1) those that can readily be set into vibrations of such amplitude as to destroy accuracy—and will inevitably vibrate considerably in actual service, and (2) those forms that are inherently stable in this respect. For metering air and gases flowing at medium velocities, and liquids flowing at low velocities, in perfectly vibrationless conduits, it is practicable to use long and slender Pitot devices, but such favorable conditions are seldom met with. For the majority

155 Crystal Speaker. A circular describing a loudspeaker which operates on the piezo-electric principle and therefore requires neither field current or polarizing voltage. The Brush Development Co., 3715 Euclid Ave., Cleveland, Ohio.

156 Mercury Switch. A leaflet describing a mercury switch which operates entirely through magnetic action and does not require moving or tipping. Providence Electric Controls, Inc., 763 Allens Avenue, Providence, R. I.

157 Ultramicroscope. An advance circular describing the unified-slit ultramicroscope, a new instrument to simplify the study of colloids. The Bausch & Lomb Optical Co., Rochester, N. Y.

158 Sperryscope. Vol. 6, No. 8 of this publication features the article, "The Ears of the Army." Sperry Gyroscope Company, Brooklyn, N. Y.

159 Water Works Journal. The April 1932 issue of this publication contains the following: "Water System of 1932 Convention City is Modern in Every Respect"; "Eureka Visible Pump Meters as an Aid in Collecting Gasoline Taxes", etc., Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

160 Glass Filters. A booklet on fritted glass filters for laboratory and industry. Fish-Schurman Corp., 230 East 45th Street, New York.

161 Stopwatches. A pamphlet dated January, 1932, describes stopwatches for research, time study, and sports. A. R. & J. E. Meylan, 264 West 40th Street, New York.

162 Photronic Relays. Circ. E-4 contains descriptions on photronic relays, Model 609 for illumination control and Model 612 for Industrial control. Weston Electrical Instrument Corp., Newark, N. J.

163 Automatic Control. A circular describing an open-hearth and stoker fired boiler equipped with automatic furnace pressure control used to eliminate the watching of too many buttons. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

164 Experimenter. The April 1932 number of this publication features the following: "Testing Radio Receivers on the Assembly Line." General Radio Co., 30 State Street, Cambridge A, Mass.

165 Testing Machines. Bulletin No. 28 gives a general survey of the Southwark-Emery Testing Machines. Baldwin-Southwark Corporation, Southwark Division, Paschall Station, Philadelphia, Pa.

166 Lathes. Junior Catalog No. 22-C describes features of the new model 9 inch junior lathes. Another catalogue identified as No. 92 describes the model series "O" lathes which are recommended for modern shop practice. South Bend Lathe Works, 435 East Madison Street, South Bend, Indiana.

167 Lathes. The 30th edition of a small instruction book issued to aid the beginner or apprentice in the machine shop and the student in the school shop to secure a better understanding of the fundamentals of the operation of a modern screw cutting engine lathe. Price twenty five cents. South Bend Lathe Works, 435 East Madison Street, South Bend, Indiana.

168 Clocks. A 4 page circular describing Tork Clocks which are motor driven and electrically timed. Tork Clocks, Inc., c/o Ward Leonard Electric Co., Mount Vernon, N. Y.

169 Recorders. Bulletin No. 112 contains descriptions and illustrations of Boiler Water Level Recorders. Bailey Meter Company, 1050 Ivanhoe Road, Cleveland, Ohio.

170 Feed Water Control. Bulletin No. 182 explains the new Bailey Three-Element Feed Water Control. Bailey Meter Company, 1050 Ivanhoe Road, Cleveland, Ohio.

171 Testing Machinery. Catalogue No. 389 contains information and illustrations of apparatus and machines for testing paper. Folder No. 408a issued by the same company has information on a beating and freeness tester which is an apparatus for determining the freeness (rate of drainage) of paper, pulp, cellulose and mechanical pulp. Also literature on apparatus for testing shrinkage and expansion of paper can be supplied by Testing Machines, Inc., 314 Broadway, New York, N. Y.

172 Viscometer. Bulletin No. 151 describes the Vogel-Ossag Viscometer used for the direct measurement of kinematic and absolute viscosities. American Instrument Co., Inc., 774 Girard St., N. W., Washington, D. C.

173 Air Tools. Catalogue AT 2000 gives prices and illustrations of air tools in use, general operating instructions for grinders, how to oil air grinders, etc. Madison Kipp Corporation, Madison, Wis.

174 Galvanometer. Circular F-145-G announces a new high sensitivity galvanometer. Leeds & Northrup Co., 4901 Stenton Avenue, Philadelphia, Pa.

175 The Graphic. No. 432 of this publication features the article, "A Survey That is Saving One Company $20,000 Every Year." Esterline-Angus Company, Indianapolis, Ind.

176 Relay. A circular describing a phototube relay developed to simplify the operation of the varied applications developed in the electronic field. Electrotée Engineering Corp., 180 Madison Ave., New York, N. Y.

177 Seri-Plane. A circular introducing an improved machine known as the "Seri-Plane" used for the determination of imperfections in textile yarns by visual inspection. Alfred Suter, 200 Fifth Avenue, New York, N. Y.

178 Hardness Testers. Catalogue R-7 and Bulletin H 9 contain information on the Rockwell Hardness Tester which is used on all metals, hard or soft, polished or unpolished, flat round, tubular, or odd in shape. For research or precision work in the laboratory or quantity inspection testing in the shop. Wilson Mechanical Instrument Co., Inc., 383 Concord Avenue, New York.

179 Testing Machines. A circular describing material testers, building testers, load measuring instruments and balancing machines. Alfred Suter, 200 Fifth Avenue, New York.

180 Gas Service Journal. Among the feature articles of the April 1932 issue of this publication are the following: "Gas Measurement and Pressure Regulation at High Pressures"; "Handling Natural Gas in Kettleman Hills Through Nordstrom Valves," etc., Pittsburgh Equitable Meter Co., 400 Lexington Avenue, Pittsburgh, Pa.

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of industrial applications we have either a tenuous fluid flowing at very high velocity, or a flowing liquid. In fact, since the Pitot type requires a micro-manometer for measuring low-velocity air or gas, industrial Pitot meter applications are characterized by an average value of γv^2 sufficiently high to warrant the employment of an industrial recorder or integrator, and for that reason alone most forms of long-stem Pitot tubes designed for test work are unsuitable as central Pitots for continuous metering in large ducts. Moreover, a common characteristic of pipes and ducts in industrial buildings is that they vibrate as long as the plant is operating. When a large pipe vibrates, any "cantilever" form of Pitot device long enough to have its head positioned at the center must be of such design and must be constructed of such materials that it will withstand this service without snapping off by reason of "fatigue." If it is resilient in order to assure endurance, its head will not only vibrate but oscillate over an appreciable angle. "Whipping" will be inevitable.

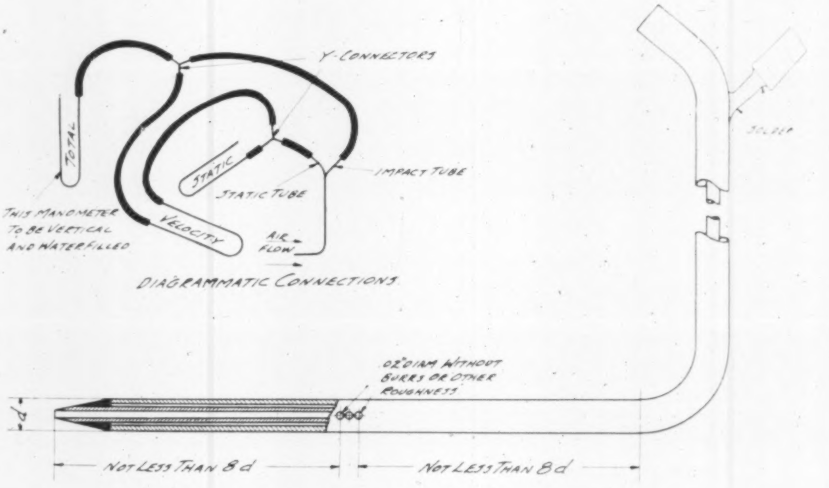

Fig. 25-88

In the absence of quantitative data (a search of the literature fails to disclose any figures on these effects of vibrations) the qualitative opinion may be ventured that it is not so much the amplitude of the vibrations or oscillations that affects the readings of velocity head, or even the relation of amplitude of vibrations to velocity of fluid flow past Pitot head, but the relation of amplitude of vibrations to *size of openings*. (Also, to some extent, the relation of direction of plane of vibration to plane of openings.) For example, a tube with 0.02-in. side openings for static pressure take-offs will become useless for Pitot metering purposes when its vibrations attain an extent which would scarcely affect the readings of a tube having ¼-in. openings. To sum up, most precision forms, when used with lengthened stems, are too "delicate" or sensitive to vibrations for reliable industrial metering, while some industrial forms with large openings can be used as central Pitots with long stems under moderate vibration conditions.

Elementary Forms.

Single-opening forms find their greatest usefulness in metering liquids. When liquids flow without disturbance in very smooth pipes at velocities under the critical, sidewall openings give the static pressure accurately, and the devices can have a coefficient of 0.97 or better. Single-openings tubes are easily constructed when the particular design and dimensions that seem called for are not commercially available. In making a "bent" tube, be sure to sharpen the edges of the impact opening and to align the axis of the head.

An easily constructed and easily installed elementary Pitot tube is made by merely plugging the end of a ⅜-in. tube and making an impact hole 1/16-in. dia. with "smoothed" but not quite "rounded" edges at a distance of ⅜ in. from the squared plugged end. Polish the last inch and avoid scratches near the opening. The coefficient is close to unity and such a tube can be readily inserted through a hole in the pipe wall. An ordinary angle globe valve with the seat removed furnishes a convenient gland through which the Pitot tube can be inserted. The opening through which the tube is installed may be used to give the static connection if there is zero differential when the impact opening is turned through an angle of 39.25 deg. either side of the pipe axis. (Fechheimer method.)

Elementary forms with long slender stems are easily set in vibration.

Combined—"Bent"—Side-hole Static Take-off.

This designation covers most of the officially adopted precision forms and also a number of serviceable industrial forms. Fig. 25-88 (which is "Plate C" of the afore-cited fan and blower Test Code) shows the prescribed dimensions. "There shall be not less than 4 orifices" states the Code.

Moss has reported at length on the combined "bent" form with side-hole static take-offs, and has made various special designs.

A generally similar form, also designed for precision measurement of air and gases, is described in Chap. 5, Sec. 6, of the A.S.M.E. Fluid Meter Report (1931 edition) from which we quote, "Perhaps the best form of combined impact tube . . . Not practical for use in closed pipes . . . The coefficient is very close to unity." This tube has a head ¼-in. outside diameter and 4½ in. long. The bend at the rear is sharp and the stem is made up of two tubes placed one behind the other instead of one within the other, which offers less obstruction to flow and gives greater "fore-and-aft" rigidity but makes a long-stem tube of this form easily set into sidewise oscillations.

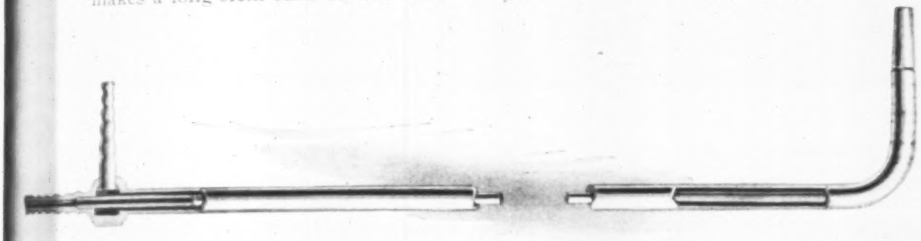

Fig. 25-89

Fig. 25-89 shows the well-known "A.B.C." tube (American Blower Co.) which is officially recognized as standard by the Am. Soc. of Heating and Ventilating Engineers. Fig. 25-90 is the Bacharach Industrial Instrument Co.'s tube of the combined bent form with side-hole static take-off, which was developed for severe industrial service such as measuring gas carrying particles of dust, etc. Connections are provided whereby compressed air or steam can be blown through the tube to clean it when necessary. A special model of this tube, made for measuring gases containing tar, such as producer gas, embodies a coil of wire which is electrically heated, thus preventing the collection of tar.

Among other special industrial forms, the Pitot device of the Blast Volume Meter (Charles J. Clark Blast Meter Co.) deserves special mention. It is shaped like a T the head of which is a large tube, located at the point of maximum velocity and properly aligned. Static pressure is taken off through the perpendicular tube or stem. The impact tube runs alongside the stem and under one branch of the head of the T, so that the static and impact openings are flush and present the appearance of a figure 8. This design makes it possible to cover both openings with a dust cap. This dust cap swings on a shaft passing through the wall of the blast pipe, so that by pulling a lever installed conveniently near the blast gage, the foundryman causes the dust cap to unmask the Pitot tube and swing far enough away to cause no appreciable disturbance of flow.

Combined—"Rod"—Side-hole Static.

There are several commercial forms on the market that come under this designation. They offer the advantage that the head containing the openings is not bent (and in some forms is considerably smaller than the rugged stem) so that they can be installed conveniently, and easily withdrawn and re-inserted. Quoting from the same section of the A.S.M.E. Report: "The static holes are obtained by side holes on a round or elliptical tube; the side holes may be arranged leading a little, to approach true static, or may be trailing a little, to give some suction effect. These tubes are critical, due to great variations at pressure connections produced by slight angular displacements." If "angular displacements" does not refer to "whipping" this is not a serious cause of unreliability in the case of a carefully built tube machined to small tolerances. Fig. 25-91 shows a tube of this classification as made by the Simplex Valve and Meter Co. The impact opening faces the flow and there are two static openings at the sides (at exactly 90 deg.). A more serious cause of unreliability, it would seem, is that the location of static holes within ⅛-in. of the

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

Introduction to Theoretical Seismology. Part II, Seismometry. F. W. Sohon, S. J., John Wiley & Sons, Inc., New York, 1932. Cloth, 9¼x6 inches, 149 pages. Price $2.75.

The practical seismologist will hail Doctor Sohon's book as filling a long-felt want. It is written by a working-seismologist and deals with the problems confronting one who wants to know what the records of his seismograph mean and how the latter must be adjusted so that it may give an accurate history of the earth movements to which it is subjected. The book adheres precisely to its title and does not enter the realm of Geodynamics which is left to a subsequent volume (PART I. GEODYNAMICS); to be issued by the author's collaborator, Dr. J. B. Macelwane, S. J.

The physical characteristics of oscillatory motion are discussed in the opening chapter with a mathematical treatment of the effect of varying degrees of damping, on the period and amplitude of an oscillation.

The author then takes up in turn the Horizontal and the Vertical seismographs. He considers the forces acting on a horizontal pendulum and considering the mass and acceleration involved sets up a differential equation for the motion of a horizontal seismometer. The relative efficiency of springs and pivots is discussed and seismologists will be interested in the conclusions even though they may not be inclined to agree with them.

The vertical seismograph and its fundamental theory is treated; the difficulties of construction and operation are outlined together with the advantages which make this instrument valuable in spite of its imperfections.

The written record comes in for its due share of attention. Driving mechanisms are noted, minute marks are discussed and also the corrections that must be applied to obtain exact times from them. The subject "Clock Correction" gives much interesting and valuable data not the least of which are the tables constructed for interpolating between successive observations of the clock rate and for obtaining the true correction for any point of time between the observations.

How the earth motion produces a magnified record takes up the matter of the fifth chapter and the conventional methods are explained with a description of practical tests. Two means employed to counteract the effect of earth tilt are given. The chapter on friction will be interesting to any user of a recording instrument for it tries to evaluate the counter acceleration produced between the stylus and the record.

The author gives a complete and simplified method for determining the constants of the Galitzin seismograph which employs a suspension galvanometer as its magnification medium. He works out the theory of galvanometric registration and describes the principle of the Wenner Seismometer which also employs the galvanometer. A detailed and practical exposition of the different methods of finding the true earth movement from Galitzin records, closes the book. An appendix describes several methods of determining epicenters of recorded disturbances.

The book is exceedingly clear in its presentation and despite its brevity is surprisingly complete and will, we feel, fulfill the purpose announced for it in the Preface, "to enable the observer to understand the principles that underlie his instrument . . . to enable him to test it, keep it in adjustment, understand its shortcomings, and give an intelligent account of its behaviour."—

J. W. Tynan

Radio Frequency Electrical Measurements. Hugh A. Brown. McGraw Hill Book Company, Inc., New York, 1931. Cloth, 6¼x9¼ in., 386 pages. Price $4.00.

In the past it has been necessary for the engineer desiring to make a particular radio frequency measurement to hunt through the scattered literature published on the subject. This has often proved a time consuming task. With the advent of this book, however, the engineer or student has at his command a complete set of the various types of radio frequency measurements grouped under the proper headings, thus making it a simple matter for him to obtain the information he desires.

The method of treatment is excellent. Instead of merely giving the reader a set of instructions on how to perform the measurement, the author has taken pains to emphasize the fundamental principles involved and to explain the theory of the methods used.

First the theory and principles of the measurement are explained, then follows a description of the method of procedure and the apparatus used; and finally a discussion which includes the precautions to be observed, the accuracy of the measurements, and the comparative advantages and disadvantages of the various methods.

The following list of chapters gives an idea of the material covered by the book. Measurement of Capacity, Measurement of Inductance, Measurement of Resistance, Measurement of Frequency, Antenna Measurements, Electromagnetic Wave Measurements, Thermionic Tube Coefficients, Electromotive Force, Current, Power, Measurement of Wave Forms, Transmitter, Receiver and Piezo Electric Measurements, and finally an Appendix. References from which some of the material was taken are given throughout the text.

For a long time there has been a need for such a comprehensive handbook on radio engineering. It can therefore be recommended as a worthwhile addition to the practicing or student radio engineer's library.—N. Nazar

Practical Microscopy. L. C. Martin and B. K. Johnson. Blackie and Son, Limited, London, 1931. Cloth, 7½x5 in., 116 pages. Price 3s 6d.

A brief outline of the theory of the microscope written in strictly conventional fashion. A few pages devoted to preparation of specimens and to interpretation of images together with other occasional suggestions as to the use of a microscope constitute the sole justification for the title. It is thought that if the space devoted to an utterly inadequate discussion of metallurgical and polarizing microscopes had been allotted to a consideration of such questions as the appropriate choice of objectives and eyepieces for specific kinds of work and the use of some of the common accessories of the microscope, it would have enhanced the value of the book.—L. V. Foster

Moderne Mehrgitterröhren. By Ing. Oskar Friedrich Roethy. Fiba-Verlag, Leipzig, 1931. Paper, 4½ x 7 inches, 191 pages. Price, RM 3.50.

In spite of the numerous publications in the field of radio technique alone, this little book will justify its appearance as it explains in very short and yet very lucid manner the principles of the many kinds of tubes used in radio transmission. Beginning with the production of electrons in an evacuated tube and briefly explaining the electron theory, two-and three-electrode tubes are discussed thoroughly and the purposes and effects of screens and girds are treated at length. In particular, the multiple-grid tubes (pentodes) are the object of this book, and in this chapter the space charge, anode reaction, the characteristics and their calculation, the space-charge grid, secondary emission, operation and amplification at high frequencies, and screen-grid tubes heated with alternating current are fully discussed with as simple mathematics as possible. It is commendable of the author, however, that he did not avoid differential formulas because without them the conciseness of the book could hardly have been attained. Also, the use of differential formulas in this book lifts it above the many "popular" cook-book type of publications. The closing part on wiring diagrams and receiving-sets to be

tip of a long "rod" makes its readings sensitive to vibrations. An interesting "rod" form in which a single static opening is located at the *end* (so that the hole runs straight up the tube) is made by the Pitometer Log Corp. for measuring water flow, particularly high velocities in large penstocks. In order to offer small obstruction to the flow the rod is of oval cross-section and the tip is flattened to a "screw-driver" shape, but with rounded corners. It is furnished with a valve to permit withdrawal and closing off.

Combined—Reversed—Symmetrical.

This designation covers many forms that have deservedly won wide popularity among industrial users. In the design of such forms, no attempt is made to take off the true static pressure: the trailing or suction opening takes off a reference pressure smaller than static. This opening is generally the same size as the impact opening—exactly the same size in perfectly symmetrical forms. Both openings usually are large, and do not readily get clogged up. Large openings minimize also the effects of vibrations. The differential head being greater than the velocity head, these tubes would seem to be especially suitable for low velocities but the coefficients of most commercial tubes of this form have been found to vary several percent at velocities under 16 ft per sec. for air. The usual coefficient, however, is fairly flat at medium and high velocities; but it varies slightly with the size of the pipe. Note that "suction" never equals velocity head, so that the differential is never twice the velocity head, but usually is from 30 to 40 percent greater.

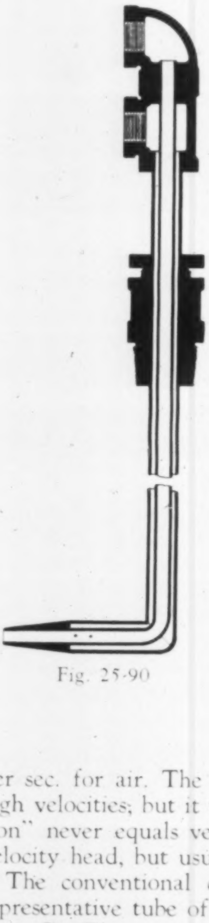
Fig. 25-90

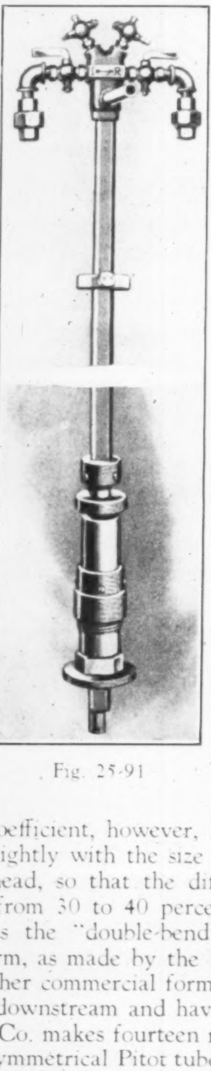
Fig. 25-91

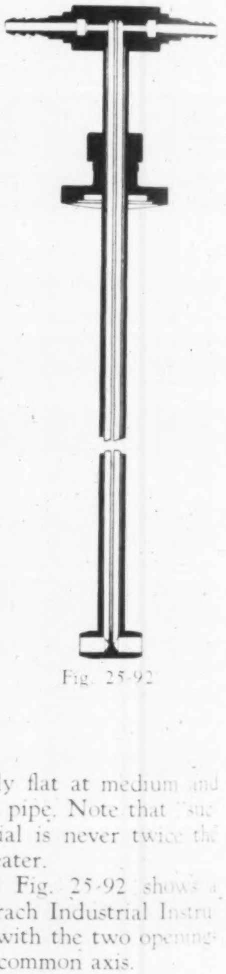
Fig. 25-92

The conventional design is the "double-bend" and Fig. 25-92 shows a representative tube of this form, as made by the Bacharach Industrial Instrument Co. There are various other commercial forms, all with the two openings facing directly upstream and downstream and having a common axis.

The Republic Flow Meters Co. makes fourteen regular (and various special) models of combined reversed symmetrical Pitot tubes for gases and liquids (Fig. 25-93); and nine regular (and various special) models for steam (Fig. 25-94). All models are readily adapted for insertion through a small hole in the pipe wall. In all models the kinetic and reference openings are the full size of the tube and are obtained by cutting the pipe on a bevel. These tubes are about ¼ in. internal diameter and so are not subject to stoppage. Another advantage of the design is that the angles can be cut in a jig and the same coefficient obtained for all tubes. There is a straight passage through the two pressure tubes so that they can be cleaned out with a wire. The tubes P-3, P-5 and P-10, all for permanent installation in pipes, are made of such length that

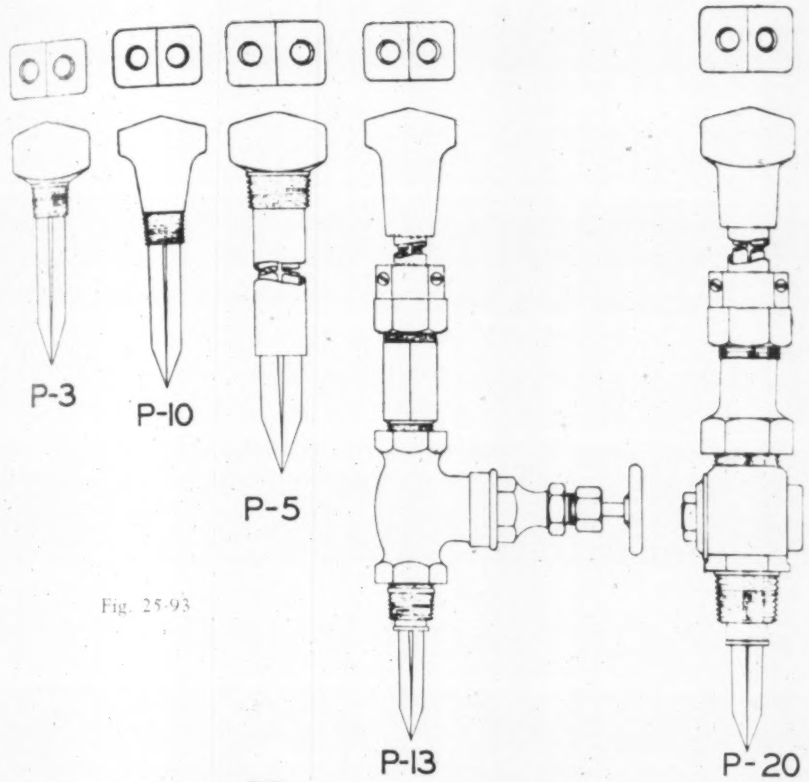

Fig. 25-93

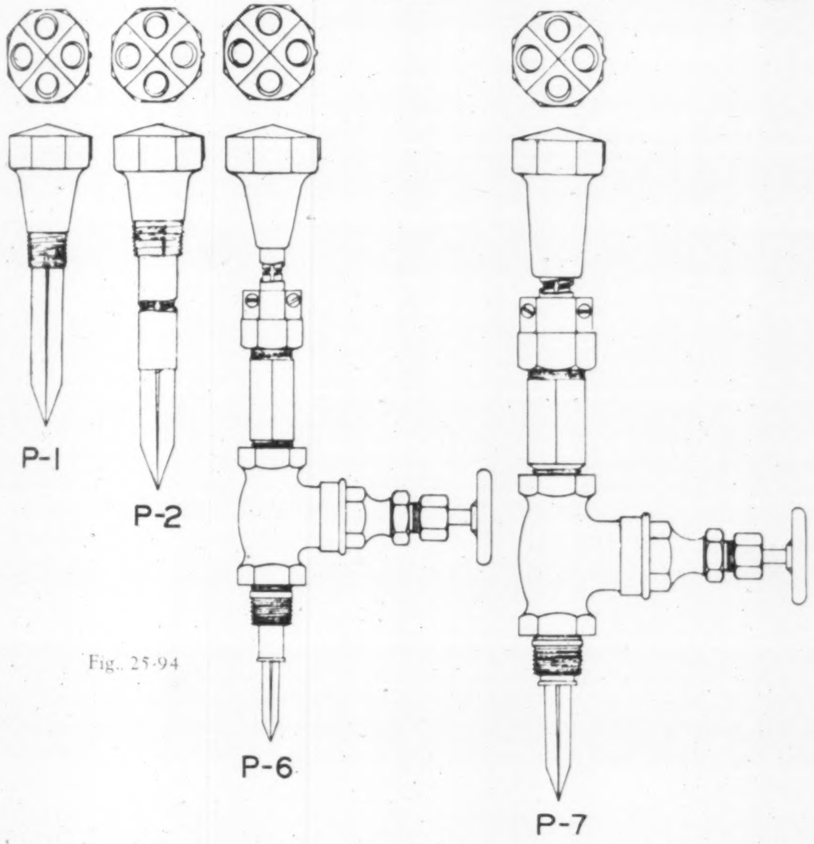

Fig. 25-94

the openings will come to the center of the pipe. It is necessary that steam or water be shut off of the line before these tubes can be installed and once installed, they must remain in place until there is a shut-down. P-13 and P-20 are removable tubes. They may be drawn back through the valve or corporation cock and then the valve or cock closed and the tube taken off and used at some other location. This form of tube is made long enough to reach entirely across the pipe and is used, if desirable, to make traverses. P-1 and P-2 are similar to P-3, P-5 and P-10 except that they have four openings in the head for the use of reservoirs for the measurement of steam. P-6 and P-7 are like-

built by the amateur gives sufficient information for him if he does not care for theory; but to have studied the simple theoretical first part will make it decidedly more fruitful for the builder to overcome and detect easily the sources of failures and troubles in his set. The 137 illustrations in this little treatise contribute much to explain in their diagrammatic manner the contents better than lengthy descriptions. In all, it will be a good book for both technical men and radio amateurs working with tubes to have handy.—

Max Hartenheim

Fundamentals of Instrumentation. By M. F. Béhar. Instruments Publishing Company, Pittsburgh, 1932. Cloth, 6x9¼ inches, 109 pages. Price $2.00.

A brief résumé of its contents best illustrates the scope of this book as a guide to better solution of production problems through measurement and control.

Chap. 1, "Industrial Instruments—General," is divided into such subheads as "The General Field of Instrumentation," "Classification by Objects of Measurement or Control," "The Role of Industrial Instruments," "Classification by Functions," and "Principal Parts of Industrial Instruments."

Chap. 2 treats of "Properties and Characteristics of Industrial Measuring Instruments." The main subheads are "The Measuring Properties of Indicating Instruments," "Behavior of Indicating Elements," "Special Characteristics of Recorders and Integrators."

Chap. 3 covers "Performance of Automatic Controllers." The scope is indicated by the section headings: "General Principles," "Departure from Normality," "Sensitiveness," "Controller Period," "Application Lag," "The Demand," "The Controlled Supply Valve," "The Power Device," "Extent of Corrective Action," "The Mode of Control," "Some Modes of Control Described," and "Selecting a Controller."

Chap. 4 is a symposium on "The Plant Instrument Department," for which contributions were especially written by Mr. Roy W. Brown, in charge of the Engineering Laboratories of the Firestone Tire & Rubber Co., and by Mr. R. E. Olson, of the Taylor Instrument Companies. The other contributions "had appeared elsewhere but are so informative that they are reprinted in whole or in part instead of merely being listed as references."

Mr. Brown discusses the subjects: "Personnel and Equipment," "Instrument Engineering and Design," "Instrument Investigation and Research," "Instrument Repair and Construction," "Instrument Maintenance," "Instrument Exchange," "Power Plants—Instruments." Mr. Olson writes on "General Recommendations."

"Controlling and Servicing the Instruments in a Coal Products Plant" by H. J. Meredith, Chief Chemist, Seaboard By-Product Coke Co., "Some Operating Views of Instrument Control," by Fred M. Reiter, Industrial Engineer, Dayton Power & Light Co., "The Instrument Department, with Special Reference to Temperature Instruments," by the C. J. Tagliabue Mfg. Co., "Number System and Index Cards," by the Weston Electrical Instrument Corp., and "Care of Portable Electrical Instruments," also by the Weston Electrical Instrument Corp., are in detail, the features of this last chapter.

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wise different from P-13 and P-20 in that they have a four-opening head. Corporation cocks are never used on steam, only cold water.

Combined—Reversed—Collins.

This form consists essentially of a straight cylindrical tube positioned diametrically across the pipe and running through two stuffing boxes instead of the usual single gland or screwed connection. An obvious advantage therefore is that the tube cannot readily be set into vibration by the flowing medium and even pipe vibrations (unless extremely severe) will not make it oscillate. Invented by A. L. Collins of San Francisco, it won considerable success on the Coast and has spread to other sections since 1919. It deserves more than a mention here, not only on account of its wide applicability, but because we cannot refer the reader to the A.S.M.E. Fluid Meter Report (which does not mention it*). One form of Collins tube is an elementary Pitot having only one opening which is used alternately as an impact opening and as a "suction" reference opening by turning the tube 180 deg. For investigating flow conditions, plotting velocity curves, etc., it is a convenient device because it can be not only pulled back and forth but turned on its own axis to face the opening at any angle to the direction of flow (any angle in a plane parallel to the pipe axis). The form which is of greatest interest in connection with practical metering applications, however, is the combined reversed tube with impact and reference openings. These openings are connected to the two legs of a manometer through the two ends of the tube (see Fig. 25-95).

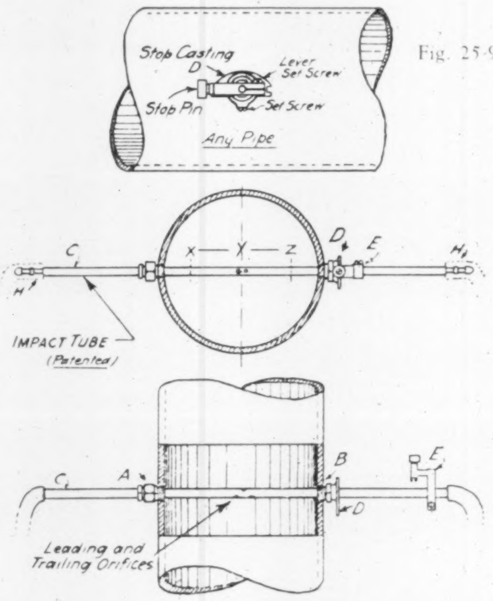

Fig. 25-95

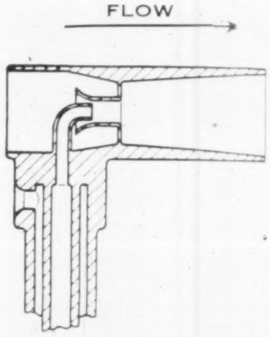

Fig. 25-96

In some models, a plug serves to partition the two halves, and the thickness of this plug prevents drilling the impact and reference openings on one common axis, so that in traversing small and medium pipes one cannot always be certain as to the exact radius corresponding to any individual velocity reading. This is a minor drawback however when one considers that the distance between the two openings may be smaller than the diameter of the openings in some other commercial Pitot tubes. Besides, this difficulty has been largely overcome in the Collins tube illustrated in Fig. 25-95 which, it will be noted, has two openings on one side and one on the other—the axis of the one being midway between those of the two. In the instructions for the use of this Collins tube, the recommendation is made that for permanent installations "the impact *orifices are* located at the point of maximum velocity . . ." which implies that the *pair* of openings is used to take off kinetic head and the single opening for reference pressure. The reason is not stated and we believe that for small and medium pipes where the velocity curve has a rounded peak rather than a "flat front" it would be better to use the single opening for impact, in order to eliminate (or at least minimize) uncertainty as to coincidence of the opening with the point of maximum velocity. It would seem that this is permissible, to judge from what the instructions state further down:

---

*We are reliably informed that it will be dealt with in the next Edition of the Report.

> At the point of maximum velocity the reversal of the orifices and the liquid columns [of the manometer] will give readings practically the same. The reversal is accomplished by pulling the stop pin in the handle of the clamp, and revolving the tube until the pin slips into the opposite notch. This reversal is also a check against the stoppage of an orifice.

Collins tubes are also made in the usual "cantilever" form, passing through one stuffing-box and projecting only part way into the penstock. From the literature it appears that these are now being used in sets of two or four—the stuffing-boxes being located at the ends of one diameter or of two mutually perpendicular diameters in one sectional plane—for metering flow in large conduits. An interesting feature of such installations is that by means of an impact pressure manifold and a reference pressure manifold, a plurality of Pitot tubes are connected to the two sides of *one* differential-pressure measuring instrument. The pressure openings are presumably located at two or four points of mean velocity but this is not essential.

Combined—Magnifying

These devices are particularly useful for metering air and gases. They "magnify" the true velocity head by utilizing the kinetic energy of the flowing stream to produce unusually strong suction effects. The result is that the reference pressure may be less than the static pressure by an amount equal to more than twice the velocity head, so that the differential reading will be more than three times the velocity head. Fig. 25-96 shows one successful form of magnifying Pitot, the Bacharach Industrial Instrument Co.'s Type TA-70 (U.S.Patent No. 1,419,798, June 13, 1922). It "consists of a small Venturi tube inserted concentrically into the pipe. To obtain a large differential pressure, the Venturi tube contains a smaller one into which projects an impact tube pointing in the direction of the flow. The impact pressure corresponding to the pipe velocity is transmitted through an opening in the side of the outer tube facing directly against the direction of the flow. The magnifying factor of this tube is 3.5 in." (*Note*—What the maker calls the "impact tube" is the suction tube or reference pressure opening according to the terminology of this text.) All such tubes must be calibrated under actual conditions of flow.

E. S. Cole's "Cosine" Form

As great an advance as Fechheimer's static tube is a newly patented Pitot device, by E. S. Cole of the Pitometer Co., which gives only the "forward" component of the flow regardless of turbulence. When properly commercialized it will no doubt make the Pitot method more popular among industrial engineers.

(f) Miscellaneous Primary Devices

Although head meters are generally divided into the four recognized types to which the major portion of this chapter has been devoted, namely the Venturi, flow nozzle, orifice and Pitot, the possible number of types is limited only by man's ingenuity in contriving devices which *produce or utilize* a differential head that is a reliable function of the rate of flow. As mentioned in Sec. 7, it is sometimes possible to make use of an existing fitting as a primary device. Any fitting such as a valve, reducer, reducing union, etc., in which there is a change of stream cross-section; any fitting such as a bend, cross-over or elbow, which causes the stream to change direction, can serve as a "primary device" but of all these the elbow is the only one that has been found practical—and then only when it takes the form of a suitable "flow bend" with smooth inner surface and carefully located taps. Still another group of fittings includes crotches, wyes, manifolds, branches, etc., whereby a portion of the stream may be by-passed (the idea being to minimize the overall loss of head) and measured by a head meter. Another type of head meter uses an orifice as a differential producer and measures the differential head by means of a *current* meter in the by-pass. Another type utilizes an orifice as a differential producer but its measuring and integrating functions depend on automatically changing the size of the orifice. Another measures a proportional flow vented to atmosphere. In the remainder of this section we can only examine a few of the many practical devices that do not belong to the four principal types.

Winter-Kennedy Taps

Used in a number of hydroelectric plants, these devices may well be selected to illustrate the measurement of flow by measuring the centrifugal head. Fig. 25-97, a typical installation diagram, is largely self-explanatory. W-K taps (Simplex Valve & Meter Co.) find their principal application on turbine scroll casings, where they are usually placed when the turbine is erected, though they may be located within the castings of turbines in place. The principle is reliable, for it has been shown that the relative velocities and pressure differential at the outer surface of the casing and near the speed ring bear a definite

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"Black" Light for Instrument Dials

STRAY light coming from the dashboards in the cockpits of small planes and in the pilot compartments of the larger ships is particularly objectionable when landing as it makes it difficult to distinguish airport signal lights. Even the dimmest of lights in the pilot's seat is many times brighter relatively than the darkness surrounding the plane, a factor which makes it difficult for him to judge quickly and accurately distances ahead and to the side. It is a condition much like that prevailing in the driver's seat of an automobile when the dash lights are too bright. The use of invisible ultra violet rays, or "black light," to illuminate the instrument board, entirely removes all stray artificial light which would shine in the pilot's eyes.

The principle of this new lighting is based on the fluorescent quality of radium paint and the characteristic of ultra-violet rays to make certain substances glow with greater brilliancy. The radium paint figures of the dials on an airplane instrument board stand out like a sore thumb when irradiated with ultra violet light. Therefore from the moment daylight becomes so weak as to make visibility of the instrument board difficult, the increased fluorescence will assure good visibility even before the arrival of contrasting darkness.

The use of invisible ultra-violet rays in increasing sharpness of the actual dial markings introduces another factor in favor of accuracy. Radium paint itself does not give a perfectly sharp line and the numerals are blurred around the edges. Ultra violet rays directed onto the radium dials remove this fuzzy outline, resulting in sharp numerals and scale divisions.

Method of Installation

Ultra-violet rays for airplane dashboard lighting are produced by merely screening out the visible light of an ordinary automobile headlight lamp. Special glass lenses placed over the mouth of a small reflector allow only the ultra violet to pass through.

A small reflector about the size of an automobile spotlight, gives enough spread to the light so that it takes in all of the surface of the dashboard. It is equipped with a two filament automobile headlight lamp which adds a factor of safety against light failure. If one of the filaments happens to fail during the flight, the pilot can merely throw a switch which will pass current through the good remaining filament and thus keep a continual source of ultra-violet.

The location of the light source is governed by the size and dimensions of the pilot's compartment or cockpit. In the big tri-motor ships they may be recessed in the ceiling above the pilot's head or in the walls on either side of the instrument board. The American Airplane and Engine Company in one of their open cockpit planes has installed the invisible light sources underneath the cowl alongside the dashboard.

The Westinghouse Lamp Company, who developed this new lighting, demonstrated the practicability of this new light on the Stinson test ship of the Pioneer Instrument Company at the Newark Metropolitan Airport.

Summer Courses in Chemical Microscopy at Cornell

The Department of Chemistry at Cornell University will offer instruction in chemical microscopy during the summer session. The equipment of the Baker Laboratory is unique in this field and affords excellent facilities for study of the various microscopic methods applicable to chemical problems, or to investigations in allied fields.

The introductory course will cover the theory and uses of the microscope and its accessories, ultra-microscopy, photomicrography, microscopic measurements and quantitative methods, crystal studies and physico-chemical phenomena, refractive index determinations, and examination of textile and paper fibers. A course in microscopic qualitative analysis, covering the reactions of the commoner metals and acids, will also be given. Both these courses will be the full equivalent of those given during the regular college year; they may be taken separately or together, or other work in the department may be carried on, according to the needs of the student.

The summer session opens July 11 and continues for six weeks, but persons not desiring university credit may cover, in a shorter period, portions of the work. Any inquiries should be addressed to Professor C. W. Mason, Cornell University, Ithica, N. Y., who will have charge of the courses.

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The A.S.M.E. for the past few months has received many requests from industry for information on lubricants and bearing testing machines and special information regarding the lubrication of advanced types of all classes of machinery. This is an indication that there is occurring all over the world increased activity in machine design and construction and a greater appreciation of the higher economies that can be secured through the proper study of a lubrication problem.

In order to meet this demand, the Lubrication Engineering Committee of the Pètroleum Division of the Society, after consultation with the leaders of various branches of industry, considered that it was advisable to prepare a complete course of instruction for the training of lubrication engineers. This course, in the form of a report, would deal with the fundamentals of lubrication and with the application of the lubricants to all classes of machinery. It would also explain the testing of such machinery to determine if the most effective lubricants have been applied and indicate how a correction of the application systems can be applied in order to bring about the highest degree of economy with the lowest possible cost for power and maintenance. This course in effect covers the same fundamentals as used in the training of the lubrication engineers for the oil companies. The report is being written and revised by the leading experts in the petroleum and allied industries and is being reviewed by the chief lubrication engineers of the important lubricating oil companies. It is now in its last stages of preliminary writing and after its acceptance by the various trade associations will be made available through the Society.

relation to the rate of flow through the turbine, although this differential probably is sensitive to the position of the valves in a ring surrounding the rotor. The head may be computed beforehand from hydraulic formulas, but in practice the head-quantity relation is checked by such methods as those of Allen and Gibson. The W-K taps are of the "flush piezometer" form.

By-Pass Devices

Whenever a portion of a stream is by-passed around a differential producer, the quantity-rates of the two streams bear a relation to each other determined mainly by the respective sectional areas and by the respective losses of head. In some cases, this method is employed in order to reduce the cost of a quantity-rate meter installation. In others it is employed to reduce the overall loss of head. In others the chief advantage is the use of a quantity meter on the by-pass, to give registration or direct index readings. The *rate* at which the index readings or registrations of such a meter *increase* is equal to the square root of the head produced by the by-pass primary device when the complete installation is properly designed and in good order. Therefore the difference between two register readings taken, say, one day apart, will give the quantity of the main flow that has passed in 24 hours, practically as if a very large positive or current meter had been installed to meter the main flow.

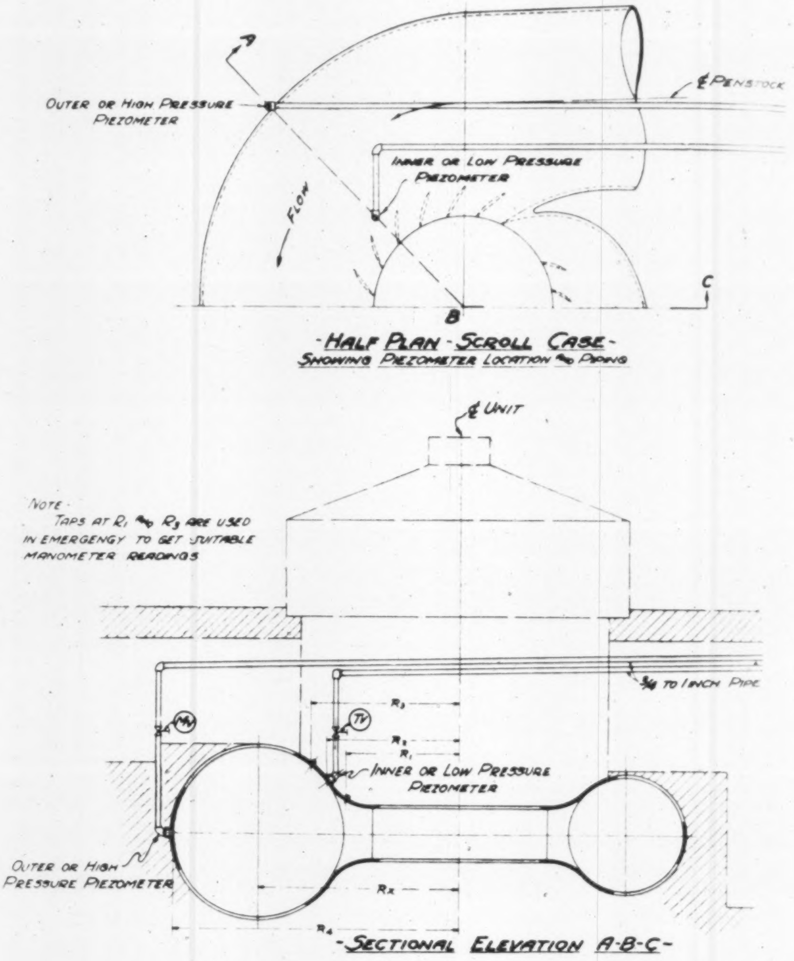
A
OUTER OR HIGH PRESSURE PIEZOMETER
℄ PENSTOCK
INNER OR LOW PRESSURE PIEZOMETER
FLOW
B
C
-HALF PLAN - SCROLL CASE-
SHOWING PIEZOMETER LOCATION AND PIPING
℄ UNIT
NOTE -
TAPS AT R1 AND R3 ARE USED IN EMERGENCY TO GET SUITABLE MANOMETER READINGS
¾ TO 1 INCH PIPE
R3
MV
TV
R2
R1
INNER OR LOW PRESSURE PIEZOMETER
OUTER OR HIGH PRESSURE PIEZOMETER
Rx
R4
-SECTIONAL ELEVATION A-B-C-

Fig. 25-97

There are commercially available devices whereby this result is achieved. We know of none which is sold separately; and for industrial service it is on the whole preferable to install the combination of a primary and a secondary device.

The National Meter Company makes a by-passed Venturi, with an "Empire" (positive-displacement) meter inserted on the by-pass. It is said to be the only meter for use on *large* mains which "does not need adjustment" (while registering volume with the accuracy that characterizes the positive-displacement meter employed). The design of the combination is such that another small meter could be substituted for the one furnished. This is likewise possible in the case of the "Shunt Meter" (Builders Iron Foundry), Fig. 25-98, in which the primary and secondary devices are compactly arranged. This meter will be described in Section 15, for it is a head meter, but attention may now be called to the primary device in the upper part of the illustration. Note that a segmental orifice is employed to produce a differential head, and that the by-pass ends up opposite the vena contracta—a design which, without excessive overall loss, provides a "pull" so reliable that the characteristic curve shows negligible departures between 10% and 150% of rated capacity.

Askania "Flow Deviator"

This device (Askania Werke, American Askania Corp., agents) is for metering compressed air and pure gases. It is interestingly unique in several respects, one of which is that it can serve as the primary element (1) of a rate-of-flow indicating or recording instrument, (2) of a quantity meter, or (3) at the same time of *both* an inferential instrument and a positive meter independent of each other except that they are elements of the same installation. Even more noteworthy, the flow indicator or recorder is not a differential manometer but an ordinary gage, and the gage pressure thus directly measured is "directly proportional" to the volume of the by-passed flow and is "a linear function" of the main flow. As to the advantages, in addition to uniformly graduated flow scales, it is claimed that the meter of which this is the primary device "is the first one yet manufactured which is capable of measuring satisfactorily a pulsating flow of compressed air or gas. It offers the only possible means of exercising supervision . . . in front of and behind piston machines, where consumption is intermittent, or where temporary fluctuations in the flow occur." It is further asserted that "even where the flow is intermittent . . . it gives faultless readings."

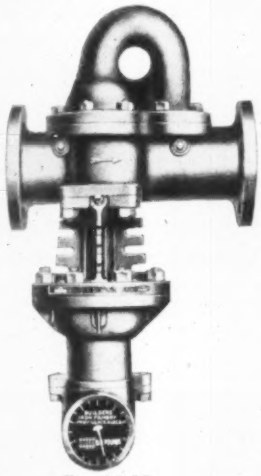

Fig. 25-98

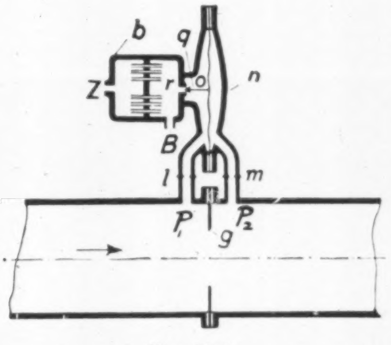

Fig. 25-99

The Askania device comprises more than a primary element, as is apparent from the schematic diagram, Fig. 25-99, in which the primary differential-producing element installed in the main conduit is an orifice plate *g*. There are in fact two other orifice plates, *l* and *m*. The head, $P_1—P_2$, produced when gas is flowing through orifice *g*, varies of course as the square of the rate of flow, but it is measured by means of other orifices and related devices so arranged, we may say, that the square root is extracted. This appears to be the general principle—which principle is not set forth in the lengthy published English description from which we take brief extracts*:

> A primary element—which may be either an orifice plate, nozzle, or Venturi tube—is installed in the pipe, the flow through which it is required to measure. This element gives rise to a differential pressure, $p_1—p_2$, when there is a flow of gas. The pressure taps are connected to the flow deviator, which contains two chambers *n* and *o*, separated by a sensitive diaphragm. To this diaphragm is attached needle valve *q*. In the upstream and downstream pressure connections there are two small orifice plates *l* and *m*, which are equal in size. While *l* performs an important function in the actual process of measurement, the purpose of *m* is merely to synchronize the filling of the two chambers *n* and *o* and to prevent overloading of one side of the diaphragm when the flow is first started or any sudden change in the pressure occurs. This prevents damage to the diaphragm or the needle valve.
>
> As soon as air or gas begins to flow through the main pipe, pressures p_1 and p_2 respectively are set up at the upstream and downstream taps and are immediately communicated to the diaphragm. Pressure p_1 in the chamber *o* (being greater than p_2) deflects the diaphragm to the right and thereby opens the needle valve *q* until a sufficient volume of air or gas has escaped through it to equalize the pressure at p_2 in the two chambers *o* and *n*. The effect of this is that in front of orifice plates *g* and *l* (read-

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*These have been severely edited to make the terminology conform to American usages. For example "by-passed flow" has been changed to "vented flow." No portion of the flow is by-passed: a portion is *vented to atmosphere.*

With the growing tendency to accept aeronautics as an every-day fact and with the increasing demand for those standards of comfort which have become the rule in the older forms of transportation, the engineers were forced to study one of the greatest factors of discomfort—vibration.

Excessive vibration leads to premature deterioration of all the structu[illegible] and accessories; erroneous indications of instruments, fatigue of structural members, and last, but not least, fatigue of the occupants.

A systematic study of this problem, both from a theoretical as well as an empirical standpoint, by Mr. Stephen J. Zand, consulting engineer of New York City, resulted in the development of a new recorder called the "Vibrograph," a photographic instrument of very small size and weight. A great number of records were obtained on many civil and military airplanes, and these data enabled him to find out ways of reducing excessive vibration and bring them to the levels which are accepted by the travelling public.

During the National Air Races in Cleveland in 1931, a paper entitled, "A Study of Airplanes and Instrument Board Vibration" was read before the Society of Automotive Engineers. This paper was considered the best aeronautical paper of the year 1931 and for this work Mr. Zand was awarded the Wright Brothers' Gold Medal, an award which is considered one of the highest among the aeronautical profession.

Mr. Zand is 36 years old and a native of Poland. He graduated in 1920 as a Mechanical Engineer from the Federal Polytechnical University in Zurich, Switzerland, and later studied aeronautical engineering in one of the government schools in Paris, France. He came to this country in 1925 and worked at the Curtiss Aeroplane Company for a year. Later he joined the Aeronautical Department of the Ford Motor Company, and early in 1929 became associated with the Taylor Instrument Company in Rochester, where he was head of the Aeronautical Department. After spending some time with the Pioneer Instrument Company as a research engineer, he established himself as a consulting engineer in New York City.

He has been lecturing in evening schools in Detroit, Rochester and New York on different aeronautical subjects. During the war, he was in the French and later in the Polish Air Service.

For the original paper, see October (1931) number of the S.A.E. Journal, page 263. A non-technical account of this work appeared in "Aviation," October, 1931, page 591.

The Franklin Institute, Philadelphia, one of the world's outstanding scientific institutions, has awarded a John Price Wetherwill Medal to **Halvor Olsen Hem**, consulting engineer of the Toledo Scale Company. The award was made, "in consideration of the ingenuity shown in perfecting scales of the pendulum type, improving their accuracy, reliability and sensitiveness, and for the application of these scales to specific purposes."

In 1915 Mr. Hem joined the Toledo Scale Company. Since that time he has designed many devices for particular weighing problems. His ability has won wide acclaim in the automotive field for which he has designed devices for balancing various reciprocating parts, such as connecting rods; in the mining field, where he devised a new system for weighing loaded mine cars and computing the amount of waste stone in the useful coal.

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Bailey Meter Company's automatic control for open hearth furnaces will be the principal feature of a display in space P-136 at the Iron and Steel Exhibition which is to be held at the William Penn Hotel, June 20 to 23, 1932. In addition to the material on automatic control, a fuel flow-air flow ratio meter and a fluid meter will be exhibited.

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Mercon Regulator Company announces appointment of the following new agents as its district representatives: E. F. Espenschied, 1008 Hill Building, Washington, D. C.; M. N. Dannenbaum, 706 Bankers Mortgage Bldg., Houston, Texas; Cowles and Company, 721 Mercantile Bank Bldg., Dallas, Texas; Boiler Equipment Service Company, 686 Greenwood Avenue, Atlanta, Ga.; Cothran-Bayles Company, Commercial Bank Bldg., Charlotte, N. C.

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Herman H. Sticht & Company have moved their offices from 15 Park Row, New York City, to larger quarters at 27 Park Place.

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The Kron Company, formerly The American Kron Scale Company of New York, and now located in Bridgeport, Conn., manufacturers of industrial scales, has just appointed George A. Nichols as their New York District Manager. Mr. Nichols will be located at 801 Chrysler Building. Mr. Nichols was formerly the New York District Manager of the Wright Manufacturing Co., of which Mr. Straw, now President of The Kron Company, was assistant General Sales Manager. The Kron Company is now building a world wide sales organization.

ing in the direction of the flow) the pressure p_1 is the same, while behind g pressure p_2 is also equal. The two orifice plates are accordingly subjected to same conditions of flow, the differential pressure as well as the static pressure temperatures being the same at both points; the constants which apply are equal in both cases, so that a definite proportion of the total flow carried by pipe passes l, such proportion being governed by the relation between the two opposed to the flow. The dimensions and calibration of the orifice plates l and arranged that the volume of air or gas passing through l shall be 0.002, 0.000 convenient fraction of the main flow passing through g.

In order that the same flow deviator may be used at different measuring poin with different pipe diameters) as well as for any desired volume of flow, the plate l fitted to the flow deviator is made interchangeable and is calibrated with precision so that it has a definite coefficient whereas the orifice plate g which the main pipe is adapted to the existing local requirements and conditions. The sions of the latter will then govern the relation between the main and the vente

When quantity metering is desired, the proportional flow passing throug needle valve q is metered by an ordinary domestic or test gas-meter connected at Z, and thence escapes *to atmosphere*, since there must not be any back pressure. (Obstructing Z would in fact make the meter inoperative.)

When rate-of-flow metering is desired,

the flow which is passing is determined with the assistance of the capillary b, which is either screwed permanently to the flow deviator (for use with gases but slightly in temperature from the surrounding atmosphere) or else fitted in cient distance behind the needle valve q. The effect of the resistance set up capillary cartridge is that the pressure in the chamber r, necessary to over resistance, is directly proportional to the volume of the flow. This pressure is at the point B, and pressure gages or recorders can be connected, and calibrated the quantity-rate of the vented flow, in cubic feet or in litres per minute. The flow, having passed through the capillary cartridge, is either allowed to escape into atmosphere at Z or else it is led on to a meter.

Thus one of the principles employed in the Askania device, in order to translate into ordinary gage pressures the rates of flow through primary device g, is analogous to that of the Pierce Critical Flow Orifice Prover (see Chapter XXIII) which is used for proving the registration rate of high-pressure positive displacement meters. The "capillary cartridge" b serves the same purpose as the standard Pierce orifice through which the gas that has passed through meter is discharged to atmosphere. Use is made in the Pierce device of the principle that when a gas passes through a (specified) orifice and the downstream absolute pressure is less than half the upstream absolute pressure, the velocity of each particle of gas at line pressure attains the velocity of sound the given gas. Empirically it has been determined that there is a relation between the quantity-rate and the upstream pressure, but the formula for (as distinguished from that for air vented to atmosphere, which is simple) no less than eight terms, one of which moreover is a factor for temperature and ratio of specific heats obtained by a second-order equation. But if the Askania device uses the gas-viscosity idea and not the Pierce idea, the quantity rate would be proportional to the pressure divided by the viscosity, but the temperature coefficient of viscosity would be a difficulty here. Moreover, the flow rate coefficient of microscopic orifices (using viscosity laws) are notoriously unreliable. Therefore it would be interesting to know how the Askania "flow deviators" are adjusted at the factory in order that an ordinary uniform scale gage connected at B can indicate the quantity-rate "under all conditions independent of changes in pressure, temperature, specific gravity . . . ." That this is actually done is implied in the assertion that "the readings are generally accurate to within ½ to 1 percent. 2 percent being the guaranteed limit error."

Linderman Method for Gas Measurement

In the Linderman Orifice Meter (American Meter Co.) the primary is an adjustable orifice of the "gate valve" form. The effective area of the orifice is changed by an electric motor so controlled that this area is always proportional to the rate of flow expressed in *standard* cubic feet per hour. The automatic mechanism being part of the meter assembly, it will be described in Section 15. The meter is mentioned here because its primary device is a distinct "type," which may be designated as the self-adjusting. A pointer attached to the gate stem travels along a vertical scale which is graduated in "corrected" volume per hour. In other words, regardless of changes in the rate of flow, in the temperature of the gas, in its pressure or in its specific gravity, the position of the gate (and hence of various secondary devices) is proportional to the rate of flow in cubic feet, at base pressure and base temperature, of gas of a specified density. This device therefore finds important applications where not only the demand varies considerably but also the temperature, the line pressure and the specific gravity of the gas. For example, a small town purchasing gas from a remote source under the usual contract but desiring to avoid the expense of the usual metering and checking methods.

NEW INSTRUMENTS

Recently Developed by Manufacturers

Write Information Section, Instruments Publishing Company, for additional Information.

Steam-Operated Controller

C. J. Tagliabue Mfg. Co.

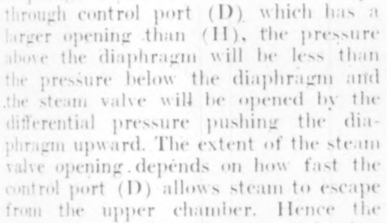
THIS new steam-operated temperature and pressure controller utilizes, without waste, the pressure of the steam to operate a diaphragm valve. Variations in the pressure do not affect the accuracy of control as a differential pressure above and below the diaphragm governs the steam valve opening.

A feature of this controller is the compact control head which houses the control port as well as the thermostatic bellows and which is claimed to eliminate leakage, corrosion and possible injury from without.

The normal position of the steam valve is closed. Steam enters the valve above the seat and passes at once into the lower diaphragm chamber through opening (K) pushing the diaphragm upward and opening the steam valve. There is also an opening (H) in the valve stem which allows steam to enter the upper diaphragm chamber. If the steam in the upper diaphragm chamber is not allowed to escape, both chambers will have the same pressure and the valve spring (L) will close the steam valve.

If, however, the steam in the upper diaphragm chamber is allowed to escape through control port (D) which has a larger opening than (H), the pressure above the diaphragm will be less than the pressure below the diaphragm and the steam valve will be opened by the differential pressure pushing the diaphragm upward. The extent of the steam valve opening depends on how fast the control port (D) allows steam to escape from the upper chamber. Hence the steam valve may be wide open, tight shut or in a throttling position.

The control port (D) is operated by the thermostatic bellows (F), a part of the usual thermostatic system which includes a bulb and connecting tube (G). (C) is a pressure equalizing bellows and seal for preventing steam from leaking through the pressure and temperature setting screw (A). (E) is a connection for control port escapement.



When the bulb is at the controlling temperature, it exerts a moderate pressure in the bellows which expands and partially closes the control port (D) allowing just enough steam to escape from the upper diaphragm chamber to maintain the correct differential so that the steam valve can pass enough steam to hold the temperature.

When the bulb is at a higher temperature than that for which the controller is set, sufficient pressure is exerted in the bellows to close the control port (D). The steam pressure in the upper and lower diaphragm chambers is now equal and the spring (L) closes the steam valve.

When the bulb is at a lower temperature than that for which the controller is set, the pressure in the bellows is reduced so that it contracts enough to open the control port wide, allowing more steam to escape from the upper diaphragm chamber than can enter through opening (H). The pressure below the diaphragm is now enough to counteract the pressure of the spring (L) and the steam valve opens wide.

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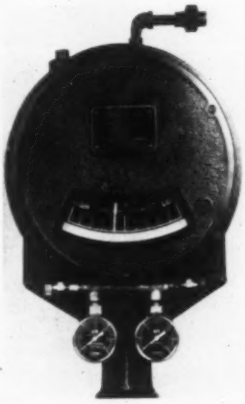
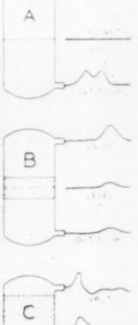
Liquid Level Stabilog

The Foxboro Company

IN CONTINUOUS process industries especially, a serious control problem has been the difficulty with which satisfactory control is obtained because of the surging flows caused by the use of incorrect types of level controllers.

This liquid level stabilog prevents these surges in flow. This instrument is made in two types: throttling and averaging. These two types can take care of a variety of level problems. Three typical examples are shown in Figures A, B and C. In each of these a constant inflow will result in a constant outflow.





The throttling type is used in processes where it is desirable to hold a close level and yet have a smooth throttling valve action that will not set up surges in the controlled flow. In figure A, the level is held exactly on the line with the result that the outflow is the same as the inflow. In some cases where a more uniform outflow is desired, the stabilog may be adjusted so that the level is held only within fairly close limits as in B. In this case any sudden change in the inflow will be partly absorbed in the vessel and the outflow will not reflect the sudden sharp changes that occur in the inflow.

The averaging type level stabilog allows the level to vary within safe limits but holds the outflow as nearly uniform as possible as in C. In this case the outflow averages out the variations in the inflow.

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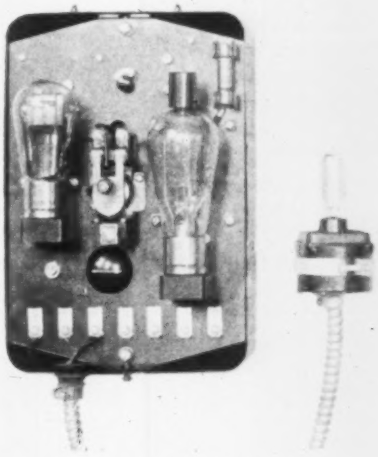
Photoelectric Relay for High-Speed Operation

General Electric Co.

A HIGH-SPEED photoelectric relay has been introduced as an addition to this company's line of electron tube control equipment. This device uses a Thyratron tube as a relay and finds its application in those operations where speed would be a limiting factor were a mechanical type relay used instead of the Thyratron.



The device is expected to be of greatest value in two general types of service: (1) where the operation proceeds at unusually high speed and a relatively small amount of current is controlled by the relay; and (2) where the speed is less although possibly still too great for a mechanical type relay and it is required that a relatively large amount of current be interrupted. In the first class of service, the Thyratron tube would serve as a relay, while in the second, the tube would actuate a contactor. Among the suggested uses are the rapid sorting, selecting or registration of objects, high-speed counting, etc.

Three electron tubes are used: a photoelectric tube which picks up the light impulse and produces a corresponding electric impulse; a Pliotron tube which amplifies the electric impulse produced by the photoelectric tube; and the Thyratron tube which acts as a relay, producing properly timed impulses to operate electric devices either direct or through the medium of a contactor.

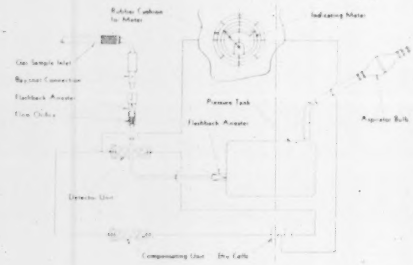
A small contactor is built into the complete device which may be actuated by the output of the Thyratron tube where necessary to control currents in excess of the rating of the Thyratron. A larger contactor may be added and controlled directly by the Thyratron tube. The device is built for operation on 110-volt, 60-cycle circuits.

Combustible Gas Indicator

Mine Safety Appliances Co.

DEVELOPED for practical use in detecting inflammable gases and vapors which are recognized hazards in many industries, this combustible gas indicator is direct reading, requiring only a few seconds to make a test. Light in weight and easily operated, this instrument is portable, and completely self-contained.

By squeezing the aspirator bulb, a sample from any desired location is drawn rapidly through the flexible metal tubing to the instrument. Up to sixty feet of sampling line can be used with the instrument for sampling from inaccessible places. There is no lag in the indicator reading except the time required to draw the sample through the length of sampling line used.



The instrument has two platinum wire filaments which are heated to a relatively low temperature by current from two dry cells, one of the filaments being exposed to the action of the gas sample. Combustible gas in the sample is oxidized or burned catalytically on this platinum wire and any increase in temperature from this combustion increases the electrical resistance of the wire. This increase in resistance is proportional to the amount of inflammable vapors in the sample and is measured by a milliameter, the scale of which is calibrated to give readings direct in percentage of lower explosive limit concentration. It will also indicate if the vapor concentration is within the explosive range and in addition, by dilution with air, if the vapor concentration is above the upper explosive limit.

ATTACH
AMPLING
LINE

The detector unit (platinum wire filaments), operating catalytically at a relatively low temperature, will last a long time with proper care. Although it is not necessary to check the zero setting of the meter very often, this can be done, easily and quickly when necessary, even in a gaseous atmosphere without returning to fresh air. The current check arrangement also insures both a definite initial temperature and applied voltage at the detector unit, so that the sensitivity of the detector unit is constant during its life.

Specially designed flame arresters are used on both sides of the detector unit so that the instrument is suitable for testing practically all inflammable gases and vapors, including hydrogen and acetylene.

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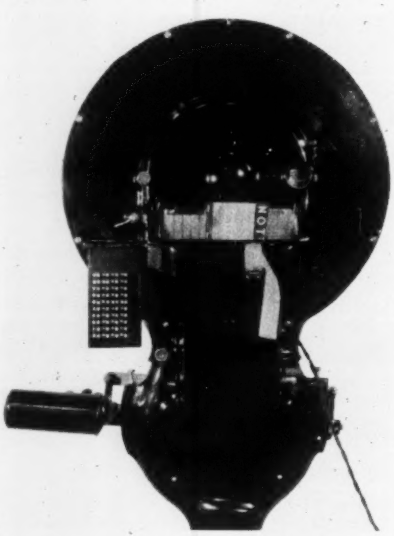
Improved Printing Scale

Toledo Scale Co.

INDUSTRIAL uses of this scale have been extended through three new improvements; a selective numbering device, a delayed time switch and the application of the photoelectric tube or "electric eye."

The selective numbering device provides a system of identification which has a variety of applications, such as dating, batch numbering, grading and numbering by lot, by operators or by employee group numbers. This improvement is a device which is composed of from one to four digits, symbols or letters. If desired, it can be furnished with decimal points or dashes to aid any system of plant control. As it is attached to the Toledo Printweigh, the operator can punch the numbers or letters he desires. These will then be reproduced on the printed weight ticket. Hence, this innovation solves many production problems by giving not only a certified weight but a certified record of the process in question.



The delayed time switch simplifies the use of the Printweigh in a conveyor system. As objects come down a conveyor line and move on a scale, the necessary moving makes the scale indicator oscillate. Hence, if the weight were printed at once, there would be a chance of inaccuracy. The delayed time switch delays the printing of the weight until the indicator has stopped oscillating. In this way, co-ordination between rapidly moving production lines and the necessary accuracy in weighing is achieved.

The "electric eye" makes the printing operation automatic if desired. Objects moving across the scale platform on a conveyor section may have their weight printed when they intercept a beam of light just before they leave the scale. Hence, the weight ticket is printed automatically.

◆ ◆ ◆

Slot Weirs and Orifice Meters

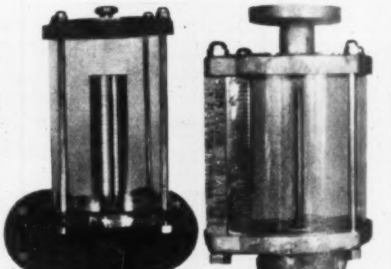
Vulcan Copper & Supply Co.

IN THE accurate measurement of flowing liquids in amounts from a few to several hundred gallons per hour, slot and orifice meters built inside a glass cylinder may be used in distillation and many other plants handling liquids.

The slot weir shown in the figure has a graduated vertical tube in which one or more slots are accurately machined. The base casting admits liquid in an annular ring around the tube which eliminates turbulence, and even at maximum capacity allows a smooth liquid surface which may be accurately read. For the accurate measurement of smaller amounts of liquids, an orifice hole is drilled near the bottom of the vertical tube instead of milling the weir slot. When a horizontal orifice is desired, this is supplied in a plate which may be screwed in the same hole as the tube.

The discharge from the slot weir and vertical orifice tubes is vented since the top of the tube is open and no syphoning or irregular discharge due to changing pressure on the discharge is possible. With the horizontal orifice, the discharge is vented by an open tube extending from the orifice plate nearly to the top of the chamber. The meters themselves have top vent connections which may be connected to the vapor space of a vessel under vacuum or pressure to allow the use of the meters under these conditions. One use in which these have served successfully has been in vacuum distillation installations.

The meters are furnished regularly in copper, bronze or other corrosion resistant materials. Each meter is individually calibrated at from 20 to 30 points and the calibration chart is furnished with the meter.



New Vibration—Voltage Converters

Brush Development Company

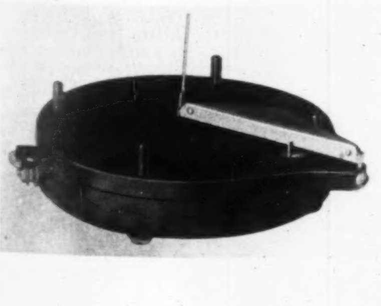
A NOVEL line of devices for converting sound or other vibrations into voltage variations, or conversely to change voltage changes into mechanical vibrations have been developed by this company.

Two standard devices are provided ready mounted; a microphone and a loud speaker motor. The microphone operates on the piezo-electric principle; it does not require button current, or polarizing voltage. It is a completely self-contained converter of sound-pressure waves into electrical energy, and contains no mechanical moving parts, as the sound acts directly on the crystal, generating a corresponding voltage, irrespective of frequency over the audible spectrum, from 10 to 10,000 cycles per second.

BRUSH CRYSTAL DEVICES
CLEV O PAT PEND

This microphone may be connected straight across the grid of the first tube of the amplifier if the amplifier is situated within 30 feet, a grid leak or volume control of at least 500,000 ohms being used. The red rubber covered wire goes to grid of tube, black wire to ground. No other shielding is necessary, even if the microphone is to be held in the hand. For most purposes the impedance of the crystal microphone varies inversely with frequency as does a condenser.

The loudspeaker motor comes complete with tone arm, ready for mounting to frame and cone. It operates on the piezo-electric principle, and therefore requires neither field current nor polarizing voltage. Electrically the crystal speaker has similar characteristics to a 0.03 mf. condenser, and may be connected directly across a high impedance choke in the plate circuit of standard pentode tubes. For other type tubes a suitable transformer must be used.



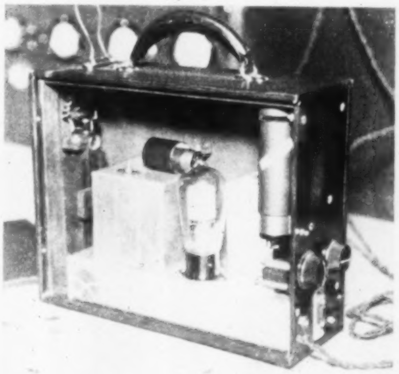
Sensitive Magnetic-Material Detector

Central Engineering Laboratories

INTENDED primarily for detecting concealed weapons or concealed tools, this device consists of 3 parts, the coil-system, the amplifier, and finally the electrical appliances or alarm signals to be actuated.

The coil-system is composed of 2 or more coils connected in series or parallel, in electrical connection with the amplifier and placed in the sash of a door or window or wherever the detection is wanted. By combination of coils in series or parallel and by shielding, any wanted characteristics and sensitivity in certain directions may be obtained.

The amplifier can be placed anywhere in the building and operates on the lighting current of 110 volts, 60 cycles. The essential parts are a galvanometer system with the input on top of the case, and a chassis with transformer, relay, grid-glow-tube, light source, and photocell on it and a double-throw-switch, adjusting and compensating condenser, and resistance, on the panel. As galvanometer a rugged concave mirror instrument is used which is connected with the coil-system but in no electrical connection with the rest of the amplifier. The relay is controlled by the lightbeam reflected from the galvanometer mirror. The lightsource is a 2 watt straight filament lamp. The photo-cell is shielded from all light with the exception of a small fine slit in the focus point of the mirror, just large enough to let the picture of the projected filament fall on the sensitive plate of the cell. The amplifier is built to keep the relay contacts under that condition open. A grid-glow-tube is used as amplifier for the photo-cell and has another function as outlined later on. The current sensitivity of the amplifier is about 0.000,000,05 amperes and is made independent of line voltage fluctuations by providing the lightsource strong enough to overcome the light-fluctuation with respect to the cell.



A piece of iron or steel approaching the coils changes the earth's faint magnetic field through the coil, which induces in the coil a very faint voltage, but one strong enough to produce a deflection of the galvanometer. This causes the lightbeam to fall off the photocell and the relay to operate. Firearms carried past the coils will therefore trip the relay, which makes the instrument a detector of concealed weapons.

By throwing the switch in the other position the unit is converted into a burglar alarm or capacity detector. Galvanometer and photocell are now disconnected and the grid-glow-tube is now used in a different hookup, utilizing its super-sensitivity for capacity changes. The grid of the tube is in that case connected to a metal plate located close to the spot to be protected. Any person passing this plate changes its capacity to ground enough to trigger the grid-glow tube, which operates the relay for sounding an alarm. A variable condenser serves to compensate for the plate capacity and adjust the sensitivity.

In addition to its applications as a protection device, this instrument is serviceable as an amplifier, in conjunction with thermocouples, for automatic temperature control. It also finds application wherever there is occasion to control power relays with microamperes or microvolts.

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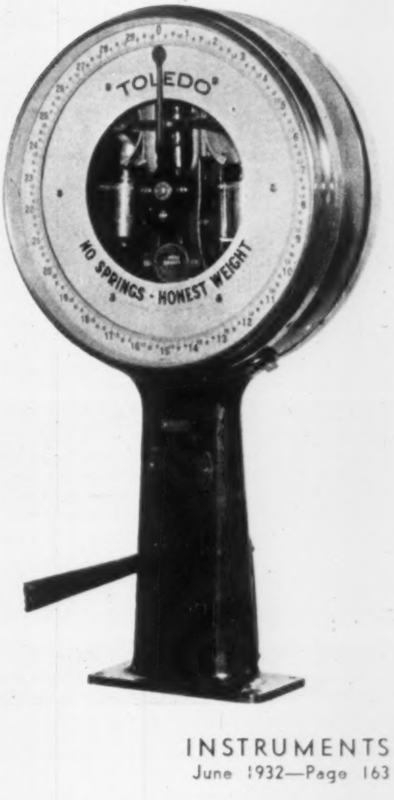
Torque Dynamometer

Toledo Scale Co.

THIS dynamometer was designed for high speed production testing of electrical starting motors: The test is to measure the stalling torque, at starting, of each motor.

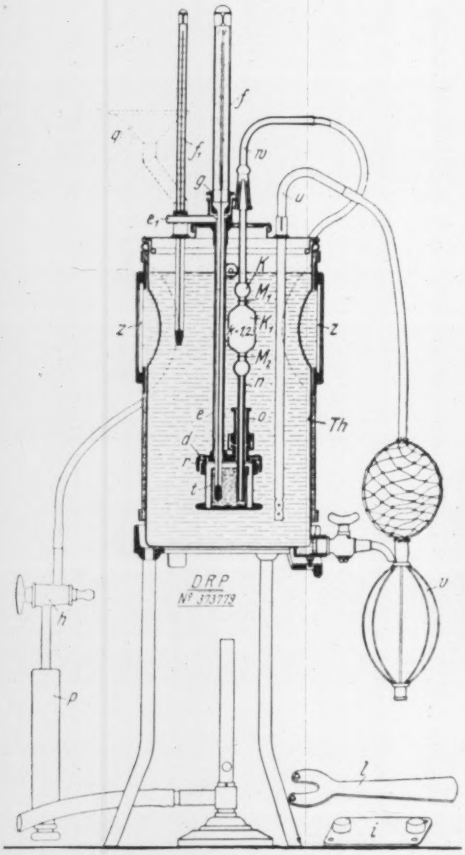
Testing procedure is as follows: The shaft of the motor is placed in alignment with a horizontal arm extending out from the dynamometer. After the motor is clamped into position by an eccentric, the sliding coupling on the horizontal arm is pushed over the shaft of the motor. The clamping device engages with a key-seat in the end of the motor shaft. Power is then applied to the motor, but it is prevented from revolving by the arm of the dynamometer to which its shaft is clamped. The downward pressure on the arm registers on the dial, and the operator reads the stalling torque. The cycle of operations in regular production requires approximately 15 seconds.



Vogel-Ossag Viscometer

American Instrument Co., Inc.

A DISTINCT feature of the Vogel-Ossag viscometer is that it permits the direct, accurate measurement of absolute and kinematic viscosities without conversion. Complete viscosity-temperature curves may be determined with the instrument without disturbing the set up. A further advantage lies in the fact that only 15 c.c. of the material are required for making a test. It also has the additional advantage of ease of manipulation and rapidity of operation. It is a compact unit which occupies no more space than the ordinary viscometer.



Both kinematic and absolute viscosities may be obtained by direct measurement with this instrument. To obtain the former, the oil (or other liquid) is allowed to flow out of the capillary under its own head, and the time of flow in seconds between two marks on the capillary tube is noted. This figure multiplied by the constant k, which is etched on the large bulb of the capillary tube, gives the kinematic viscosity V_k in centistokes. To obtain absolute viscosity, the oil (or other liquid) is driven upward through the capillary by a constant pressure of 60 cm. of water. The time of flow in seconds between the same two marks (M_1 and M_2) multiplied by the constant c, likewise etched on the capillary tube, gives the absolute viscosity in centipoises.

Engler, Redwood, and Saybolt viscosities may be accurately obtained from either of these readings by means of a simple conversion table supplied with the instrument. The Vogel-Ossag viscometer hence also provides an absolute standard for checking oils and for checking routine test instruments for accuracy.

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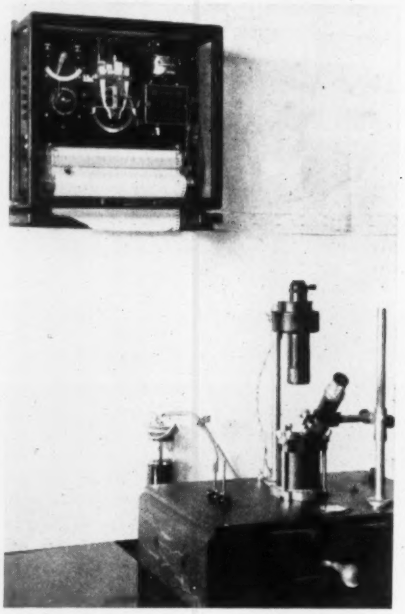
Portable Micropyrometer

Westinghouse Electric and Mfg. Co.

A MICROPYROMETER under development at the Westinghouse Research Laboratories, determines the melting points and viscosity of metals and alloys much more accurately than other devices of its sort. Designed particularly to study the characteristics of welding slag, it is expected to find many applications in other fields.

In operation a minute test piece of welding slag or alloy is placed on the platinum strip, which is suspended from two insulated terminals, and current applied from the low-voltage winding of a step-down transformer. The heating chamber is gas-tight since the melting point determinations are made in various atmospheres or a vacuum. Observation is made by means of a microscope with a magnification of 100 to 1, through a clear quartz window. When fusion is seen to begin, the current is shut off.

Temperature is automatically recorded on a chart by an ardometer (total radiation pyrometer) which collects the heat rays passing through a quartz window and focuses them on a disc containing thermocouples leading to the recording instrument. Readings are taken in millivolts and read in degrees centigrade from a curve previously plotted from readings taken of metals and alloys with known melting points.



The instrument consists of a heating chamber in the form of a brass cap clamped by thumb screws to a brass base; a heating element, which is a platinum strip 0.5 in. wide and 0.0005 in. thick; a microscope for viewing the beginning of fusion; and an ardometer for registering temperature.

Control of the current is handled on the high-voltage side of the transformer; hence the current in the control apparatus is small. On the low-voltage side it has a range up to 40 amperes. A motor-driven rheostat, also operable manually, controls the voltage applied to the primary and provides a steady increase of current during a test. The motor speed may be varied to suit conditions. The micropyrometer as a unit is portable.

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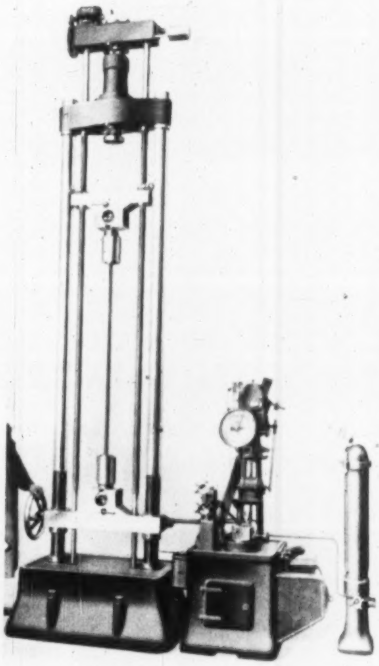
Universal Testing Machine

Steel City Testing Laboratory

THIS NEW model of an earlier machine is especially adapted for general testing. Due to its flexibility in that both pulling heads are adjustable, a great variety of specimens can be tested, such as standard specimens of cable, wire, etc.

For making transverse and bending tests, a suitable table can be supplied which can be removed, if desired, when tests in compression are to be made. Some of the outstanding features are the flexibility of the entire pulling head which has a ball joint between the upper crosshead of the machine and the piston, thus assuring a direct pull on all specimens; the adjustability of the upper pulling head the entire length of the supporting screws through the medium of the motor mounted on top of the upper crosshead; pendulum dynamometer load-indicating dial and autographic attachment, all functioning as one unit; elimination of pulsation in applying the load to the specimen by use of pressure from the accumulator; and non-packed frictionless plunger and time attachment in the load-indicating dial for regulating speed of tests.



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Abstracts on instruments and devices for measurement, inspection and control.

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Upon receipt of the abstracts they are checked against permanent files to avoid duplication and after being rewritten to conform to our style they are classified.

Oftentimes an abstract can fit under two or even more sections. In that case we decide who will be most interested in the article, and include it under that field of reader interest. It is our aim to so arrange the abstracts that a person interested, for example, in viscosity, will keep in touch with all the important articles in his field if he reads only section 2.10. For instance, an article on "Vacuum Tube Means of Measuring Viscosity" appears under 2.10—under "Measurement and Control of Physical Properties—viscosity," although it would also fit under section (5.4)—"Electronic Devices and their Applications."

An improvement we hope to make in the Abstracts Section in the near future is the cross-indexing of articles which fit under several sections. We suggest glancing through the whole Abstract Section. This takes but a short time, and the time so taken will be found very profitably spent.

The classification number at the end of each abstract will be of assistance in mounting them on file cards.

Negative print photostats of the original articles abstracted can be obtained at 35 cents per page plus 10 cents for mailing. The remittance should accompany the order.

CLASSIFICATIONS

(By Fields of Reader Interest)

MEASUREMENT TECHNOLOGY (1)

This section includes all matters concerning the art and science of measurement as follows:

Measurement Theory (1.1)

Under this heading will be included: definitions, precision of measurements, systems of units, and dimensional analysis.

Measurement Practice (1.2)

Covers Calibration and Standardization.

Calculation (1.3)

This does not include computation for instrument design, but covers calculations as a mode of measurement.

MEASUREMENT and CONTROL (2)

This section is devoted to those general measurement practices and control applications that are not confined to any one industry or branch of engineering. Thus temperature measurement and control, being of as much importance in chemical as in metallurgical processes, is a general field of interest to all industries and all branches of engineering.

Length, Angle, and Area, Including Surveying (2.01)
Time, Speed, and Acceleration (2.02)
Weight, Density, and Specific Gravity (2.03)
Pressure and Vacuum (2.04)
Flow and Volume (2.05)
Temperature (2.06)
Heat and Combustion (2.07)
Humidity and Moisture (2.08)
Power, Work, and Output (2.09)
Physical Properties, (Viscosity, hardness, elasticity, plasticity, surface tension, etc.) **(2.10)**

TESTING and INSPECTION (3)

Physical Testing and Inspection (including strength tests, bending, magnetic analysis, X-ray inspection, and other engineering test or inspection methods.) **(3.1)**
Production Testing and Inspection (This includes methods of testing and inspection for setting up production standards, grading, gaging, maintaining quality, etc.) **(3.2)**
Maintenance Testing and Inspection (Included here will be matters concerning standards and methods for controlling performance or service of equipment. Example—The problem of controlling long phone lines to give quality sound transmission would be included here.) **(3.3)**

ELECTRICITY and MAGNETISM (4)

Electrical Properties, Tests, Measurements, and Measuring Instruments (4.1)
Electrical Measuring Devices and Applications (4.2)
Magnetic Measurements (4.3)
Magnetic Properties, Materials, and their Applications (4.4)

ELECTRONICS and RADIO (5)

Radio Measurements (5.1)
Applications of Radio to Measurement and Control (5.2)
Photo-electric Measurements, Devices and Applications (including television) **(5.3)**
Electronic Measurements, Tubes, Devices, and their Applications (Under this heading would be included thermionic tubes, grid-glow tubes, thyratrons, neon discharge tubes, cathode-ray tubes, etc.) **(5.4)**

ACOUSTICS and VIBRATIONS (6)

Sound, Vibration, Phenomena and Measurements (6.1)
Sound and Vibration Devices or Applications (6.2)

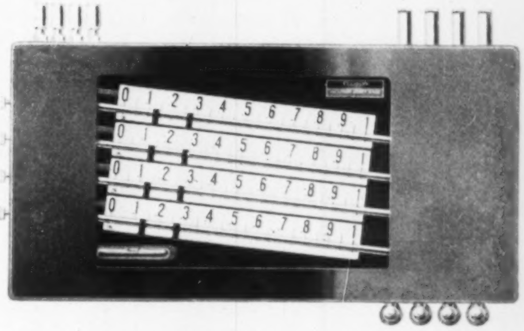
LIGHT, OPTICS, and RAYS (7)

Light—General Measurements and Optical Applications (7.1)
Color Analysis, Color Matching (7.2)
Photometry (7.3)
Polarimetry (7.4)

(Continued on page A15)

ELLISON
ACCURACY

Ellison Inclined Draft Gage

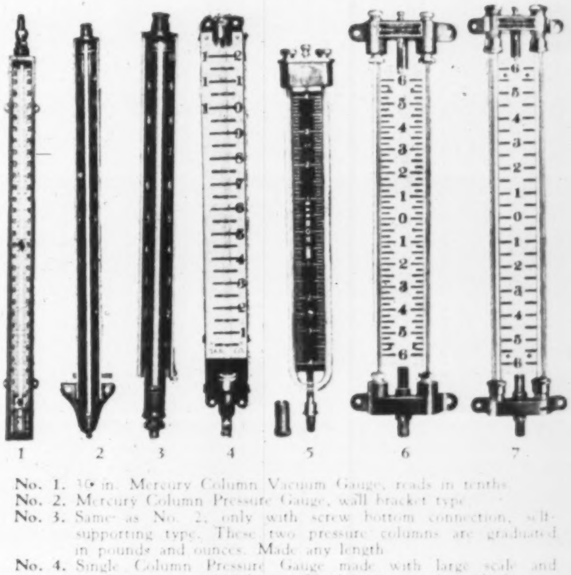


The Ellison Inclined Draft Gage, introduced in 1896, is a masterpiece in design and finish. It is the original inclined tube gage and is the recognized standard of accuracy everywhere. The cover type for stationary use is made in from one to four tubes, ½ to 7½ in. range, and the open type for portable use in one and two tubes from ½ to 20 in. range.

Made by an engineering organization
of draft gage designers and builders

Ellison Draft Gage Company
214 WEST KINZIE STREET CHICAGO

Defender Manometers



No. 1. 30 in. Mercury Column Vacuum Gauge, reads in tenths.
No. 2. Mercury Column Pressure Gauge, wall bracket type.
No. 3. Same as No. 2, only with screw bottom connection, self-supporting type. These two pressure columns are graduated in pounds and ounces. Made any length.
No. 4. Single Column Pressure Gauge made with large scale and numbers, uses red Oil as a Fluid and is made with ½ in., ⅝ in. or ¾ in. Gauge Glasses. From 4 in. to 60 in. high.
No. 5. Portable Test U Gauge with Water Scale, made in two models with leather carrying case. Pocket size.
No. 6. Mercury Double Leg Manometers made any length.
No. 7. Oil Manometers made with any size or length Glasses.

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MEASUREMENT & CONTROL (2)

Time, Speed & Acceleration (2.02)

The New Suspension Device for the Foucault Pendulum in the Vienna State Museum. (Die neue Aufhaengevorrichtung für das Foucaultsche Pendel des Naturhistorischen Staatsmuseums in Wien.) R. Pozdena. *Zeitschrift für Instrumentenkunde,* Vol. 51, Aug. 1931, pages 430-434.

Previous pendulae experiments. New suspension device employing the precision roller bearing. EF (2.02)

A New Mono-Metallic Escapement with Compensation Effect Based on Thermal Anisotropy. (Eine neue mono-metallische Unruhe mit Kompensationswirkung durch thermische Anisotropie.) R. Straumann. *Zeitschrift für Instrumentenkunde,* Vol. 51, July 1931, pages 379-380.

Refers to a lecture delivered at the Meeting of the Gesellschaft für Instrumentenkunde und Uhrentechnik, Kassel. The compensation effect of the new escapement is accomplished by rolling the material in a certain direction, resulting in the phenomenon of thermal anisotropy, i. e., the material shows markedly different coefficients of thermal expansion in different directions. The following materials are considered: elinvar, single crystals of metals, Zn-Cu alloys with 3-5% Cu, Zn-Cd alloys containing 20% Cd. Related problems as degree of rolling, heat treatment, aging phenomena, X-ray structure, etc., are dealt with. EF (2.02)

A New Recording Acceleration Meter on the Piezo-Quartz Plate System. (Ein neuer registrierender Beschleningungsmesser nach dem Piezo-Quarzplatten-System.) Rich. Ambronn. *Feinmechanik und Prazision,* Vol. 39, Dec. 1, 1931, pages 199-204.

An instrument is described with which the vibrations of foundations can be measured very exactly and curves recorded; the theoretical principles are explained. Ha (2.02)

Visible Speed Indicator. Wm. Ochse. *American Machinist,* Vol. 75, Sept. 3, 1931, page 387.

The provision of devices so that the workman can always see the speed of his machine directly is recommended as a means for speeding up production. Ha (2.02)

The Importance of a Standard of Time. (Die Wichtigkeit eines Normalmasses der Zeit.) Max Schuler. *Feinmechanik und Prazision,* Vol. 39, Dec. 1, 1931, pages 205-208.

The author points out that actually no standard of time exists, as what is usually called the standard, namely, the second, is in fact dependent on the astronomical and sidereal differences in what we call a day; but yet the sidereal day, 86,400 seconds, is at present the best standard. A pendulum, however, was devised, an "equalizing pendulum," built of a piece of invar steel which changes not more than $1/100\mu$ for lm; it is driven electro-magnetically. With a photocell the time can be determined to 1/1000 of a second exact. The importance of having a measure of time absolutely independent of eventual fluctuations of cosmic influences for astronomical, physical, and geophysical measurements and the art of dock making is explained. Ha (2.02)

Weight, Density & Specific Gravity (2.03)

Methodic Principles Involved in Density Measurements of Solid Bodies, Particularly of Inorganic Salts. (Methodisches zur Dichtebestimmung fester Stoffe, insbesonders anorganischer Salze.) P. Wulff & A. Heigl. *Zeitschrift für physikalische Chemie, Section* A, Vol. 154, March 1931, pages 187-209.

Determinations made with the pyknometer disclosed that errors of about 1% are inevitable, particularly in the case that relatively large quantities of salt are used. The source of error is considered to be the air adherent to the salt employed. The estimation of the error yielded the same value as is computed from data given in the literature and gained from the suspension method or from X-ray determinations. The suspension method is claimed to be improved owing to holding the temperature constant and due to a more convenient and reliable handling of the liquid. An accuracy of 2/10% of the true density value could be attained, according to the investigators. It is furthermore shown that, in the case of high specific gravities, an accuracy of 1% can be secured with the buoyancy method, employing presumably a spring scale. 20 references. EF (2.03)

Measurement of Specific Gravity of Liquids. (Messung des spezifischen gewichts von Flüssigkeiten.) Jos. Kroenert. *Archiv für Technisches Messen,* 1931, Section V9121-1, page 26.

Weighing methods and buoyancy methods are described and araeometer scales explained. Ha (2.03)

Gain in Sensitivity of Lever-Scales by the Utilization of a Horizontal Pendulum. (Erhoehung der Empfindlichkeit der Hebelwage durch ein Horizontalpendel.) G. Schmernitz. *Zeitschrift für Instrumentenkunde,* Vol. 51, Aug. 1931, page 435.

Based on theoretical considerations the author arrives at the conclusion that a material increase in sensitivity of a beam-scale can be secured by the utilization of a horizontal pendulum placed perpendicular to the scale-beam in the center of the latter. EF (2.03)

Pressure & Vacuum (2.04)

Investigations on the Evaluation of Pressure, Temperature, and Atmospheric Pressure Diagrams in the Measurement of Large Gas Quantities. (Untersuchung über die Auswertung der Druck-, Temperatur- und Luftdruck-Diagramme bei der Messung grosser Gasmengen.) H. Brandl. *Gas & Wasserfach,* Vol. 74, No. 43, Oct. 24, 1931, pages 995-998.

Five formulae covering the reduction of gas quantities to the normal state. Reduction of average values, gained by planimetry. Description of the automatic instrument "Volumsreduktor." EF (2.04)

Throttling Devices as Pressure Indicators. (Drosselgeräte als Messdruckgeber.) G. Ruppel. *Archiv für Technisches Messen,* 1931, section 1241-1, pages T3, T4.

Throttling devices are: diaphragm, or orifices, nozzle, Venturi tube. The characteristics of each type are explained, the formulas for their performance derived, the influence of viscosity and compressibility, and the sources of errors discussed. The practical applications are described, coefficients given and literature references added. Ha (2.04)

Flow & Volume (2.05)

Measurement of Velocity of Water Streams by the Salt Velocity Method. (Geschwindigkeits-Messung von Wasserläufen nach dem Salzgeschwindigkeitsverfahren.) G. Ruppel. *Archiv für Technisches Messen,* 1931, section V1249-1, page T-17.

The method consists in measuring the velocity of a cloud of salt which is taken along by the water and causes current impulses in electrode circuits placed in the water due to its better conductivity. The method can be used in closed pipe lines and open channels. The evaluation of the measurements and the limitation of the method is explained; the apparatus and electrical connections are described. Ha (2.05)

Flow Measurement in Pipes. (Durchflussmessung in Röhren.) G. Ruppel. *Archiv für Technisches Messen,* 1931, section V1240-1, page T2.

The principles, definitions and units used for the measurement of the flow of a liquid or gaseous material in a pipe are explained; the formulas for a flow of volume and flow of weight are derived, taking into account static pressure, humidity content in gases, viscosity and compressibility of the material to be measured. Ha (2.05)

Temperature (2.06)

Temperature Measurement With Seger Cones. (Temperaturmessung mit Segerkegeln.) W. Steger. *Archiv für Technisches Messen,* 1931, section V215-1, page T50.

Seger cones (refractory cones) are used for temperature measurements in industrial furnaces for a range from 600 to 2000° C. in 59 steps. For the measurement, three cones of adjacent ranges of about the temperature to be measured are put in the furnace where they are protected from the flame. A table of comparison between refractory cones used in America, Germany, England and France is given. 5 references. Ha (2.06)

Quick Acting Electrical Thermometer. *Industrial Chemist,* Vol. 7, Apr. 1931, page 173.

A brief description of a new thermometer manufactured by the Cambridge Instrument Company, utilizing their new platinum resistance thermometer element. RAW (2.06)

Determination of Melting Points. (Schmelzpunkt-Bestimmung.) M. Pirani & R. Rompe. *Archiv für Technisches Messen,* 1931, section V9215-1, page T27.

In determining the melting point of a substance the temperature must be measured and the transition from the solid to the liquid state observed; the latter can be ascertained by mechanical change of form (melting), by the thermal effect due to the heat of fusion, by the change of the electrical resistance, by the change of the optical properties. All these methods are useful; they are explained, and a table of melting points for substances from — 123.5 to ± 3490° C. is given. Ha (2.06)

Flow-Pyrometers. (Durchfluss-Pyrometer.) Jos. Kroenert. *Archiv für Technisches Messen,* 1931, section J242-1, page T45.

The temperature of a combustion gas cannot be measured directly with a pyrometer or thermo-couple on account of the radiation losses, except with certain precautions for protection against radiation. Several devices are described and coefficients or curves for the correction of the pyrometer reading dependent on the gas velocity are given. Ha (2.06)

Temperature Measurement by Measuring Radiation. (Temperaturmessung durch Messung der Strahlung.) Jos. Kroenert. *Archiv für Technisches Messen,* 1931, section V214-1, pages T8-9.

The principles of the theory of radiation, the laws of Boltzmann, Stefan, Planck, Rayleigh-Jeans, Wien, and the black body are briefly explained and the methods of spectral measurement, total radiation, partial radiation, flame photometer, Wanner and glowing filament described. Ha (2.06)

Heat & Combustion (2.07)

Measurement of Heat Value of Solid Fuels. (Heizwert-Messung bei festen Brennstoffen.) Jos. Kroenert. *Archiv für Technisches Messen,* 1931, section V9214-1, page T14.

The heat value is determined either indirectly from the chemical analysis and then calculated with Dulongs' formula or a modification of it, or the value is determined directly in a calorimeter. The methods are described and the procedures explained. Ha (2.07)

Planning, Construction and Operating Results of Combustion Regulators on a 1000m.^{2} Water Tube Boiler. (Planung, Bau, und Betriebsergebnisse von Feuerreglern an einem 1000m.^{2}-Steilrohrkesse.) K. Weiss. *AEG-Mitteilungen,* Dec. 1931, pages 680-685.

Steam pressure, CO_2 content, economy and efficiency were greatly increased after equipping the plant with the regulator. Ha (2.07)

Heat-Meter. (Waermezaehler.) A. Lion. *Die Umschau,* Vol. 35, Oct. 31, 1931, pages 879-881.

Treats two European commercial heat recorders based on two principles: (a) measurement of thermo-electric currents; (b) changes in evaporation speed. 4 illustrations. EF (2.07)

An Electric Reflection Furnace. (Ein elektrischer Reflexionsofen.) C. Benedicks & J. Harden. *Zeitschrift für technische Physik,* Vol. 12, April 1931, pages 234-243.

The authors designed an electric reflection furnace mainly consisting of an elliptical mirror of Cu (42 cm. in diameter, water-cooled) and an electric arc. The following advantages are claimed: (1) non-conducting materials are melted without being in touch with foreign material; (2) short time required for attaining the melting temperature; (3) temperatures exceeding 2,000° C. are easily attained; (4) utilization for melting in vacuo. A large number of experiments were carried out. The efficiency amounted to 25% of the input, i. e., of the energy required for the electric arc, presumably the Cu-mirror was in a highly polished state. EF (2.07)

THE REVIEW OF SCIENTIFIC INSTRUMENTS

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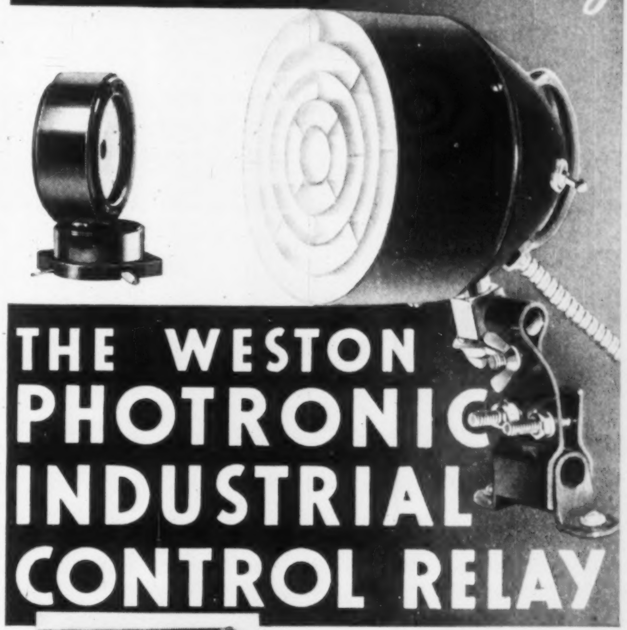

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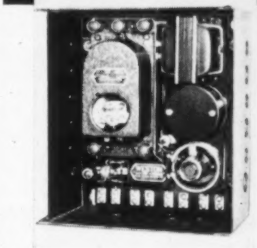

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Humidity & Moisture (2.08)

Humidity Measurement. (Feuchtigkeits-Messung.) H. Gruss. *Archiv für Technisches Messen,* 1931, section 1283-1, pages T34-35.

The theoretical principles of the determination of humidity in gases are explained and the methods of the dew-point hygrometer, the psychrometer and the hair-hygrometer described. 9 references are cited. Ha (2.08)

TESTING & INSPECTION (3)

Physical Testing & Inspection (3.1)

Testing Machines for Building Material and Exhibition of the Pruefmaschinen-Verband. (Baustoffpruefung und Ausstellung des Pruefmaschinen Verbandes.) H. Sperber. *Tonindustrie Zeitung,* Vol. 55, No. 55, July 9, 1931, pages 799-802.

Reviews the more important commercial testing machines for building material (grain size, compression and bending strength, wear resistance, resistance to penetration and other physical properties) shown at the recent Exhibition, Berlin. Includes 9 illustrations. EF (3.1)

Densifying Methods and Densifying Agents for Engineering Construction. (Abdichtungsverfahren und Abdichtungsstoffe für Ingenieur-Bauwerke.) R. Vogeler. *Tonindustrie Zeitung,* Vol. 55, No. 67, Aug. 20, 1931, pages 958-960; Vol. 55, No. 68, Aug. 27, 1931, pages 972-973.

The interest of the Testing Engineer is attracted by the Third Part of the paper, which shows a testing (pulling) machine for densifying material developed by the Chemisches Laboratorium für Tonindustrie, Berlin. Furthermore, a standardized equipment for testing the resistance towards water penetration is discussed. EF (3.1)

Production Testing & Inspection (3.2)

Testing of Paints for Bending Strength and Adhesion. (Zur Prüfung von Anstrichen auf Biegefestigkeit und Haftvermögen.) R. Kempf. *Oberflächentechnik,* Vol. 8, Dec. 1, 1931, page 247.

Description of an apparatus in which a thin steel ribbon on which the paint to be tested is put is continually moved in an S-shape between 2 rollers so that the paint is bent back and forth. It can be used for other materials, also. Ha (3.2)

Maintenance Testing and Inspection (3.3)

X-Ray Testing of Large Boilers in Service. (Röntgendurchstrahlung im Grosskesselbetrieb.) A. Herr. *Zeitschrift Verein deutscher Ingenieure,* Vol. 74, Oct. 11, 1930, pages 1432-1433

An arrangement is described whereby large tanks, drums, etc., are tested by X-rays on site. The X-ray tube is installed in the interior and exposures on films taken on the outside. One exposure lasted 30 min. at 145 KV. The films were 15x40 cm. Ha (3.3)

Automatic Testing Equipment for Trunk Circuits. E. R. Lundius, *Bell Laboratories Record,* Vol. 9, Aug. 1931, pages 589-592.

Description of the automatic testing arrangement of the proper condition and functioning of the relays in the trunk lines and subscriber stations. Ha (3.3)

Location of a Failure in High-Tension Transmission Lines. (Fehlerort-Bestimmung an Hochspannungs-Freileitungen.) H. Polleck. *Archiv für Technisches Messen,* 1931, section V35194-1, pages T21-22.

The nature of possible failures are described and the methods of the location of the fault by measuring current and voltage, reactive resistance or conductivity, reactive and active components, and by calculation of the failure diagrams explained. The instruments used, possible errors and the measurement by surges are described. Ha (3.3)

ELECTRICITY & MAGNETISM (4)

Electrical Properties, Tests, Measurements, & Measuring Instruments (4.1)

Moving-Coil Instruments for Direct and Alternating Current Measurements with Thermo-Electric Transformer. (Drehspulinstrumente für Gleich und Wechselstrommessungen mit thermoelektrischen Umformer.) *Die Messtechnik,* Vol. 7, Apr. 1931, pages 112-113.

The Excelsior Werke Rudolf Kiesewetter, Leipzig (Germany), have developed a series of instruments for the measurement of very weak alternating currents by means of direct-current instruments. For this purpose the alternating current at first heats a wire which in its turn heats up a thermo-couple which is connected to the moving coil of the direct-current instrument. The construction of the instrument is described. Ha (4.1)

Tests with New Small Recording Instruments. (Versuche mit neuen kleinen Registriergeräten.) K. Holzwarth. *Die Messtechnik,* Vol. 7, April 1931, pages 97-99.

These little instruments are equipped with a bi-metal measuring part which develops a large torque and is therefore very suitable for recording. The comparatively high inertia gives clearer curves, which is better for general purposes than if all details would be recorded as is necessary for recording of actual operation conditions. For simple supervisory diagrams of general operations this type is considered to be superior to the electrodynamic instruments. Ha (4.1)

Slide-Wire Measuring Devices with Increased Adjusting Accuracy. (Schleifdraht-Messeinrichtungen mit erhohter Einstellgenauigkeit.) Otto Zwierina. *Elektrotechnik &, Maschinenbau,* Vol. 49, March 8, 1931, pages 181-185.

By arranging an auxiliary resistance of the same magnitude as that of the slidewire itself and which can be short-circuited, the wire is much better utilized as it can be used with the two auxiliary resistances in circuit, over almost its whole length instead of only about a third, with the same accuracy. The method is explained, and the Wheatstone bridge apparatus and potentiometers equipped with it are described. Ha. (4.1)

The Calculation of the Alternating Current Resistance of Iron Wires. (Ueber die Berechnung des Wechselstromwiderstandes von eisernen Drähten.) I. Antik. *Archiv Elektrotechnik,* Vol. 25, Feb. 31, 1931, pages 125-129.

From theoretical considerations a few empirical formulas are derived which give with sufficient practical accuracy the resistance and self-induction of iron wires for a frequency of 50 cycles per sec. Ha. (4.1)

Present Trends in Construction and Application of Instrument Transformers. (Gegemoärtige Bestrebungen in der Konstruktion und im Gebrauch von Messwandlern.) M. A. Iliovici. *Elektrotechnik & Maschinenbau,* Vol. 49, June [illegible] 1931, pages 473-474.

A survey of the recent improvements for increasing accuracy in current transformers by reducing errors in the ratio of transformation; and in high-tension voltage transformers by reducing the leakage flux due to the large distances between high and low voltage windings. 5 references. Ha. (4.1)

Reactive Power Measurement or Power Factor Measurement in the Operation of Power Station? (Blindleistungs- oder cos-Messung im Kraftwerksbetrieb?) A. Kle[illegible]. *Elektrotechnische Zeitschrift,* Vol. 52, Oct. 22, 1931, page 13[illegible].

The author suggests the measurement of the reactive power rather than that of the power factor because with distorted current or voltage curves the actual phase angle is not identical with the power factor and because, particularly, the instruments are very complicated and require readings in the four quadrants while the reactive power can be measured much more simply. A monographic chart is developed for the determination of the power factor from readings of effective and reactive power. Ha (4.1)

Simple Method for Experimental Analysis of A.C. Waveforms. (Enifaches Verfahren zur experimentellen Analyse von Wechselstromkurven.) Th. Laible and E. Binder. *Elektrotechnische Zeitschrift,* Vol. 52, July 16, 1931, pages 939-940.

This method makes possible the determination of harmonics without having to take an oscillograph of the wave. It consists in superimposing on the voltage curve to be analyzed another voltage curve of almost equal frequency and voltage so that the resulting voltage has a very low frequency, one period in several seconds. An indicating instrument therefore oscillates slowly between two values U max. and U min. from which the amplitude of the desired harmonic, ax, can be calculated, with the known effective voltage, Uf of the superimposed voltage, from ax = (U^2max — U^2min) /4 × Uf. The arrangement of instruments is described fully. It can also be used for the determination of the maximum amplitude of any of the higher harmonics besides that of the principal wave, and also for the fixation of the whole curve. Ha. (4.1)

The Calculation of Cylindrical Coils. (Ueber die Berechnung von zylinderspulen.) Art. Mueller. *Elektrotechnik & Maschinenbau,* Vol. 49, Jan. 11, 1931, pages 29-30.

A formula is developed which permits calculating the self-inductance and dimensions of one-layer coils with sufficient practical accuracy. Ha. (4.1)

Dependence of Frequency of Spark-Gap Voltage in Air. (Frequenz abhaengigkeit der Funkenspannung in Luft.) Hans Lassen. *Archiv Elektrotechnik,* Vol. 25, May 9, 1931, pages 322-332.

The spark-gap voltage in air is measured at atmospheric pressure at frequencies of from 100,000 to 3,000,000 Hz and voltages up to 15,000, and compared with lower frequencies. For the same distance the voltage remains at first the same as that for direct current; at a certain critical frequency it decreases to a value of 20% for spheric electrodes and 14% for plate electrodes, where it remains constant for higher frequencies. For each distance the range of the decreasing voltage is another one. The measuring method is described. 15 references are cited. Ha. (4.1)

Accurate Measurement of Small Electric Charges by a Null Method. Lauriston S. Taylor. *Bureau of Standards Journal of Research,* May 1931, pages 807-818.

In the use of an electrostatic system for measuring charges and currents, it is necessary to know the electrostatic capacity of the system. For small capacities the error in this measurement may easily be 1 per cent. There is here described a new method for calibrating a null system in such a manner that the capacity of the leads does not enter and which therefore permits a reduction in the calibration error to one-tenth. When a system is once calibrated in the manner described, any unknown capacity whatever may be added to the leads without affecting the measurement of the desired quantities. Expressions are given for the sensitivity of the system in terms of readily measured quantities. Applications to the measurements of current, charge and capacity are discussed. (4.1)

A New Form of Cross-Coil Instruments. (Eine neue Form von Kreuzspulinstrumenten.) Heinz Gruss. *Wissenschaftliche Veröffentlichangen aus dem Siemens-Konzern,* Vol. X, 1931, pages 137-152.

A comparison of the behavior of galvanometers for measuring small changes of resistance discloses the superiority of the bridge method over differential methods with regard to sensitivity. An instrument is described which combines the advantage of the bridge method, i.e., the greater accuracy, with the advantage of independence of indication from the voltage across the instrument; another advantage is that it responds to even smaller changes of resistance than the cross-coil instrument of Bruger. The new instrument is also free from temperature errors. This has been obtained without loss of torque so that it is superior to the moving-coil instrument; further, it is arranged in such manner that it can also be used as simple moving-coil instrument. The theory of the instrument is derived in detail. Ha (4.1)

Series Testing-Desk for Alternating Current Meters. (Serieneichpult für Wechselstromzähler.) *A E G-Mitteilungen,* May 1931, pages 330-331.

The A. E. G., Berlin, describes a table and the electrical equipment for arranging a number of meters in series for testing. Ha (4.1)

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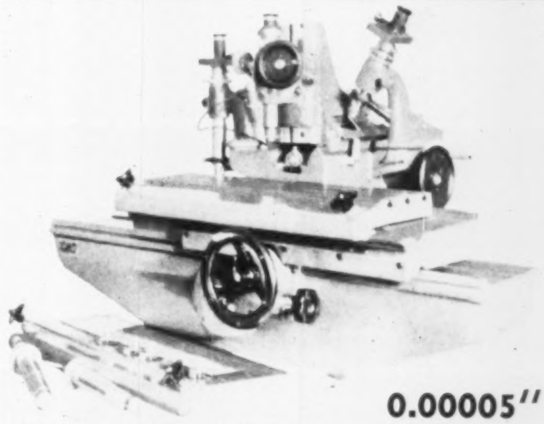

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Study of Sphere-to-Grounded-Plate Spark Gap. (Ueber die Funkenstrecke "Kugel-Platte geerdet" mit Abschirmungen.) H. KASTENBEIN AND W. KELLERMEYER. *Elektrotechnische Zeitschrift,* Vol. 52, July 23, 1931, pages 969-970.

This spark-gap is investigated and it is found that this combination gives more reliable voltage curves than the usual sphere-sphere arrangement, particularly if screens of certain arrangements were used. An equation for the voltage is derived and calibration curves reproduced. Ha. (4.1)

High Voltage Testing Plant. *Electrician,* Vol. 106, Feb. 13, 1931, pages 240-241.

The necessity for testing insulation and cables at the highest pressures has resulted in the designing of special equipments to meet these particular conditions. The Oerlikon Co. has built equipments for pressures ranging between 200,000 and 1,000,000 volts.

The 1,000,000 volt installation at their own works, and the 200,000 volt installation for the Societe d'Exploitation des Cables electriques at Cortaillod, Switzerland, are briefly described. WHB (4.1)

Experimental Investigation of Electrostatic Fields. (Experimentelle Untersuchung elektrostatischer Felder.) JOH. LABUS. *Archiv Elektrotechnik,* Vol. 25, Jan. 27, 1931, pages 17-20.

A bridge arrangement is described by means of which, according to Green's theory, the potential within a two-dimensional or centrically-symmetrical electrical field can be determined at any place; this method is applicable even where analytical methods fail. The theory is explained and the bridge and the measurement described. Pictures of distribution of the electrical field of transformers are reproduced. Ha. (4.1)

ELECTRONICS & RADIO (5)

Photo-electric Measurements, Devices & Applications (5.3)

Optimum Outputs of Photo-Sensitive Devices. EARL D. WILSON. *Review of Scientific Instruments,* Vol. 2, Dec. 1931, pages 797-806.

The terms "power sensitivity" and "voltage sensitivity" are defined for photoelectric elements in a circuit, and a mathematical expression is derived to evaluate each of these characteristics for the three classes of light-sensitive devices—photo-conductive, photo-emissive, and photo-voltaic. The conclusion is reached that, under normal illumination and a practical size cell, none of the photo-sensitive elements have the power sensitivity to operate a dependable relay. The selenium bridge and gas-filled cesium cell come nearest to doing so. Voltage sensitivity of both photo-emissive and photo-conductive cells is adequate to work a relay thru one stage of vacuum tube amplification, the photo-emissive cell being in this respect the better. The photo-voltaic cell is poor for this purpose, but has the advantages of being self-contained and possessing a power-sensitivity that increases with light flux. HO (5.3)

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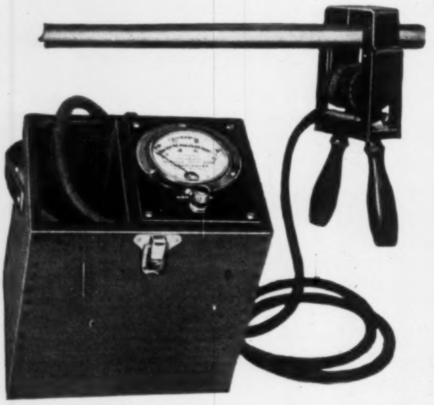

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Photo Cells and Thyratrons. L. J. DAVIES. *Electrician,* Vol. 106, June 26, 1931, pages 936-938.

The growing importance of vacuum devices is indicated. The many applications of electric "eyes" and "arms" are pointed out. This paper deals with the use of the photo-cell-thyratron combination. The thyratron is a modification of the common 3-electrode wireless valve. Characteristic properties of valve and thyratron are tabulated and show the outstanding differences lie in the current handling capacity, the working voltage drop between anode and cathode and the nature of the grid control. All of these differences are due primarily to the use of the gas filling of mercury vapor which results, during operation, in the production of positive ions by electron bombardment. WHB (5.3)

Electronic Measurements, Tubes, Devices, and Their Applications (5.4)

Universal Tube Test Equipment. O. H. BREWSTER & K. F. MAYERS. *Electronics,* Vol. 3, Nov. 1931, pages 198-199.

A testing desk with meter and control panel is described in detail; grid emission, ionization and dynamic characteristics of tubes can be tested. Ha (5.4)

An Automatic Testing and Sorting Machine for Amplifier Tubes. (Eine selbsttatige Prüf-und Sortiermaschine für Verstarkerrohren.) W. TRAUB & F. MENZLER. *Elektrotechnische Zeitschrift,* Vol. 52, Oct. 8, 1931, pages 1277-1278.

An entirely automatic machine is described with which all types of tubes, including screen-grid tubes, can be measured and sorted according to defects. The tubes are placed on a rotating device and the measurements are made in 10 different positions of the tubes for insulation, vacuum, anode current, grid current, ionization current. The capacity of the machine is 1800 tubes per hour. The special relays which were necessary for the small currents, and the diagram of connections are explained. Ha (5.4)

Grid-Current Measurement. LEE SUTHERLIN. *Electronics,* Vol. 3, Oct. 1931, page 148.

Describes an amplication method with special tubes which must have a high degree of insulation. Currents of the order of 10^{-14} amperes can be detected. Ha (5.4)

Measurement of Vacuum in Radio Tubes. M. D. SARBEY. *Electronics,* April 1931, pages 594-595.

The vacuum in finished tubes can be measured by the inverse current which flows in the grid circuit when the latter is negative with respect to the filament. This current originates from the ionization of the gas in the tube and is therefore essentially proportional to the gas contents of the tube. The current is of the magnitude of a few hundreds of a micro-ampere, so that it can not be measured with ordinary factory methods. A method is described in which, by means of known quantities in the circuit, and knowing the time it takes a condenser to discharge, the current can be easily calculated from the formula. If this value is divided by the average plate current, the ratio can be designated as tube constant or ionization factor, and is proportional to the gas in the tube. Ha (5.4)

A Device for Obtaining Very Small Electric Currents of Known Magnitude. LLOYD P. SMITH. *The Review of Scientific Instruments,* Vol. 2, No. 4, April, 1931, pages 237-241.

A new vacuum tube which yields currents of the order of magnitude 10^{-12} to 10^{-15} amperes is described in detail; the circuit is illustrated and a graph of the results is published which shows excellent linearity characteristics. The useful features of the tube described are: (1) It delivers very small currents of known magnitude over a large current range. (2) Its capacity is very low (2 micro micro farads) making it useful for the calibration of electrometer measuring systems or for using the electrometer as a null instrument. (3) It is capable of delivering currents of either sign. MFB (5.4)

Life Testing of Vacuum Tubes. G. H. ROCKWOOD. *Bell Laboratories Record,* Vol. 9, March 1931, pages 320-324.

A complete description of the arrangement of test-boards for making periodical tests of vacuum tubes for cathode or filament temperature, protection against short-circuits between filament and grid and plate circuits. The whole arrangement is mounted on a little car. Ha (5.4)

Cathode-Ray Oscillograph Tests Arrester Production. O. ACKERMANN. *Electrical World,* Vol. 97, May 9, 1931, page 866.

A cathode-ray oscillograph is being used in connection with a surge generator for the purpose of testing each block in the production line before it is assembled in the arrester. The Westinghouse apparatus used is of the glass tube type with a filament heated cathode and is operated at 4000-5000 volts. The impulse, impressed on the arrester element, is generated by a 50-kv. surge set of .28 mfd. capacity. A single operation inserts the arrester block into the surge circuit, and closes primary and secondary contacts. The corresponding volt-ampere curve appears on the fluorescent screen traced in about 1/50,000 of a second by the deflection of the cathode-ray beam in proportion to voltage and current in the arrester. The screen bottom of the cathode-ray tube is partly covered by a mask on which limits of characteristic coördinates are marked in heavy black lines. The lower line marks the potential below which the arrester should not pass current, the upper line the voltage to which the arrester must reduce the impressed surge. The ratio of the two ordinates is 2.5:1. The maximum current for this test is 500 amperes. If a volt-ampere curve at any point extends beyond the lower or upper limit set by the characteristic horizontal lines the particular arrester block is rejected. Changes in characteristics are associated with small fluctuations in the composition of the fundamental ingredients or in processing. The indications given by the oscillograph disclose these departures at once and the processing of the units is under immediate control.

WHB (5.4)

Instruments Abstracts Classification

(Continued from Page A9)

Spectrometry (7.5)
Photography (7.6)
Microscopy (7.7)
Electromagnetic Rays (This heading covers all electromagnetic rays other than visible light: infra-red, heat rays, ultra-violet, X-rays, alpha, beta, gamma, cathode, and cosmic rays.) **(7.8)**

CHEMISTRY (8)

Under this heading will be chemical measurements, analysis, and their control applications.

ASTRONOMY, NAVIGATION, AVIATION (9)

Included in this section will be, besides usual matters concerning astronomy, navigation and aviation, special matter on direction-control such as range finding, direction finding, radio beacons, etc.

GEODESY, GEOLOGY (10)

In this section will be covered seismology, geophysical prospecting methods, etc.

INSTRUMENT DESIGN and CONSTRUCTION (11)

Matters concerning new instruments, their design, operation and manufacture, will be included under this heading.

GENERAL and MISCELLANEOUS (12)

This section will include: First; general items of interest to all in the field of measurement and control. Example—"Possibilities of Vacuum Tubes for Application to Measurement and Control" is an article of universal interest in the fields of measurement and control. Second; miscellaneous items of general interest because not includable under any of the above classifications. Finally, items of general interest to all fields of measurement and control, such as historical material, biographical, etc.

General (of interest to all in measurement or control fields) **(12.1)**
Miscellaneous (12.2)
Historical and Biographical (12.3)
Bibliographical (12.4)
Economic (12.5)

CONTROL FUNCTIONING EQUIPMENT (13)

Literature on the equipment used by operators or automatic controllers to perform their control functions will be covered under this heading. For example, the drum controller and associated switches, rheostats, relays, and motor starters by which an operator controls the motion of a crane are all pieces of "control functioning equipment."

Mechanical Control Functioning Equipment (13.1)
Electrical Control Functioning Equipment (13.2)
Includes drum controllers, relays, solenoids, etc.

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A Sensitive Wood Element Hygrostat

(Continued from Page 144)

elements become stressed to the point where the instrument has to be readjusted or the elements replaced.

As previously pointed out, under a fluctuating condition of about 10° at about 70°F., hygrostats using wood as the hygroscopic element can only be expected to control relative humidities to within 2%. This particular design approaches these limitations in the control of relative humidity and the useful temperature range of the instrument is only limited to the temperature at which the hygroscopic nature of the wood is destroyed.

The hygrostat cannot be used throughout wide ranges in temperature without some adjustment or some compensation being made for the variations in length of the element at various temperatures. Wood is very sensitive to thermal changes, and though its coefficient of thermal expansion is not large, it is sufficient so that when a long element is used a wide temperature fluctuation causes a change in control setting. Under normal operating conditions a 5° or 10°F. temperature variation does not change the control sufficiently to warrant the introduction of compensating thermal devices.

SIGNIFICANCE

The value of this or any other type of hygrostat lies in the ability to use the instrument to control conditions of equilibrium or relative humidity which in many cases is more important than the control of temperature. In the drying of wood, for example, there are many instances where variations of temperature of 10°F. are immaterial insofar as the drying is concerned, but if such a temperature variation results in a wide variation in equilibrium moisture content conditions, considerable harm may result in the way of damaged stock. In this case the hygrostat controls the more important equilibrium moisture content conditions, which, with a 10° temperature change, would not result in damaged lumber but only in increasing or decreasing the drying rate.

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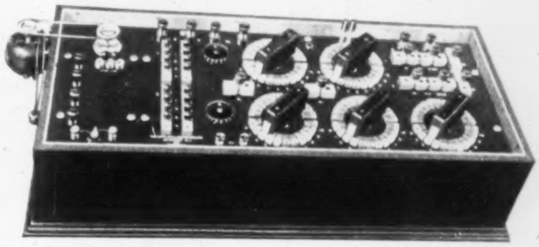

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HERE'S A LINEAR TIME AXIS FOR THE G-R CATHODE-RAY OSCILLOGRAPH

Unusual brilliancy of image is an important feature of the General Radio cathode-ray oscillograph. Now these brilliant patterns are made available for observing and photographing the true shape of high-frequency alternating-current waves by means of the new sweep circuit.

The Type 506-A Sweep Circuit is described in the May issue of the General Radio EXPERIMENTER. Write for your copy.

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High-Voltage Surge Testing—The Cathode-Ray Oscillograph. F. D. Fielder. *Electric Journal,* Vol. 28, Feb. 1931, pages 106-107, 119; Mar. 1931, pages 161-164.

The cathode-ray oscillograph accurately measures voltage and time relationships. It depends for its operation on the influence of electric fields upon an electron beam. The Dufour and Norinder types are illustrated and their operations outlined. The deflection of the cathode rays made by an electric field is a positive motion and oscillograms indicate an accuracy of 2%. The 3-electrode gap permits the operation of the Dufour type oscillograph for the cathode voltage, the test wave, and the timing system voltage within 1 microsecond. The operation is simple and consistent when care is used in circuit design and adjustment. In synchronizing circuits, the most complex system is the combination of the Dufour type oscillograph and single-sweep timing. The essential parts of the system are shown in a figure. WHB (5.4)

The Time-Deflection in Braun-Tubes. (Ueber die Zeitablenkung bei Braunschen Röhren.) G. Hauffe. *Electrotechnische Zeitschrift,* Vol. 52, April 2, 1931, pages 446-447.

The time-deflection, i.e., the abscissa of diagrams of the Braun-tube is usually obtained by the discharge of a condenser through a resistance; the plates for the deflection of the cathode-ray are connected to the condenser. The properties of this time scale are discussed as function of the constants of the condenser circuit and the conditions determined for a certain required drop in potential during the discharge period. Ha (5.4)

The Study of Non-Periodic Phenomena with the Cathode-Ray Oscillograph. (Die Aufnahme nichtperiodischer Vorgänge mit dem Kathoden-strahloszillographen.) H. E. Hollmann. *Archiv Elektrotechnik,* Vol. 25, Oct. 12, 1931, pages 689-694.

The method is based on the arrangement that the cathode-ray is deflected in the time axis by tilting oscillations and that the phenomenon to be analyzed is periodically connected and cut off by a tilting relay at definite points of the time axis. A few examples illustrate the operation of the instrument. Ha (5.4)

The High-Tension Supply of the Cathode-Ray Oscillograph. (Ueber die Hochspanunngsanlage des Kathodenoszillographen.) K. Beyerle. *Archiv Elektrotechnik,* Vol. 25, Oct. 12, 1931, pages 708-710.

The change of the exciting voltage at alternating load of the high-tension supply influences the accuracy of the oscillograph. The magnitude of the disturbances is investigated and means discussed to obtain a more uniform high-tension supply. Ha (5.4)

The Photo-Electric "Eye" in a Steel Mill. *Machinery,* Vol. 38, Nov. 1931, page 206.

A photoelectric cell is used at the plant of the Bethlehem Steel Co., Lebanon, Pa., to actuate the mechanism for cutting the bars. When the end of the bar passes over the cell the bars are cut. The length is varied by shifting the cell. RHP (5.4)

The Electron Tube in Machine Design. Raymond Francis Yates. *Machinery,* Vol. 38, Oct. 1931, pages 95-96.

General discussion of application of the vacuum tube, photo-electric cell, and the grid glow tube in wire drawing, automatic sorting and counting devices, and motor control in rolling mills. Mentions control of elevators and valves but does not elaborate. RHP (5.4)

A Periodic Contactor Operated by a Neon-Tube Oscillator. Herbert J. Reich. *Review Scientific Instruments,* Vol. 2, March 1931, pages 164-170.

This device is capable of closing a circuit periodically at any desired frequency and holding it closed for any desired fraction of the cycle. The plate current of thermionic vacuum tube charges a condenser; when the potential across the latter is equal to the flashing potential of the neon-tube it begins to glow and its resistance drops to a very low value, allowing the condenser to discharge rapidly to the lower critical potential, the extinction potential of the tube, below which the tube again becomes non-conductive. Then the condenser charges again, and so forth. This cycle repeats at a frequency which depends on the value of the plate current of the tube, the capacity of the condenser and the characteristics of the neon-tube. The frequency of the oscillation is controlled by varying the capacity of the condenser or the plate current. The UX-171A type of tube has been found most satisfactory for this purpose. The full equipment used in the author's experiments is described. A saw-tooth voltage of frequency up to about 5000 per second could be obtained. (Ha 5.4)

Large Cathode-Ray Oscillograph for 200 KV Deflection Voltage. (Gross-Kathodenstrahl-Oscillograph für 200 KV Ablenkspannung.) L. Binder. *Elektrotechnische Zeitschrift,* Vol. 52, June 4, 1931, pages 735-736.

When investigating very rapidly passing phenomena as f.i. arcing, spark-gap breakdowns, insulator testing, etc., it had been found desirable to have the high-voltage connected to the deflecting system. Such arrangement for 200,000 volts is described; in this way the disturbing oscillations which are originated when a voltage divider is used are entirely eliminated. The apparatus has been built in the high-tension laboratory of the Technical University, Dresden, and consists essentially of a drawn brass tube of 300mm. inside diameter and 2200mm. length closed by brass plates. Within the tube, the ray producing chamber, deflection, and photographing chamber are arranged. Ha (5.4)

Self-Contained, Accessible Automatic Oscillograph. *Electrical World,* Vol. 98, Aug. 22, 1931, page 352.

A new type of oscillograph for recording automatically all fluctuations on power systems is manufactured by the Westinghouse Electric & Manufacturing Co. This type "PA" is more accessible, more flexible, and easier to adjust than the power Osiso and operates within ½-1 cycle of a 60-cycle wave after the appearance of a fault. Any mechanical quantity translatable into an electric one may be recorded. Characteristics are: speed, gear-drive from an integral motor, low cost, utility, simplicity and compact daylight loading film. WHB (5.4)

Photoelectric Cells in Chemical Technology. A. J. McM[illegible]. *Industrial & Engineering Chemistry,* Oct. 1930, pages 1070-1[illegible].

The vacuum cell and the gas-filled cell are discussed and performance characteristics are given. Diagrams are given to illustrate the use of the photoelectric cell in: 1) a circuit in which the photoelectric current itself is used to actuate a sensitive electrical instrument; 2) a circuit in which the photoelectric current actuates a radio-tube amplifier, thereby increasing the magnitude of the current which can be used to control a meter, relay, or other electrical device. Applications are given. MEH (5.4)

Process Control with the Electric Eye. C. A. Styer and [illegible] H. Vedder, *Industrial Engineering Chemistry,* Oct. 1930, pages [illegible]-1069.

The photoelectric cell is described in relation to some of its many applications in plant and process control. MEH (5.4)

Fitting Photo-Electric Tubes into the Scheme of Automotive Production. J. Geschelin. *Automotive Industries,* Vol. 64, Jan. 10, 1931, pages 64-66.

The article points out the manifold applications of photo-electric cells in the automotive industry. Photo-electric tubes manufactured by the Westinghouse Electric & Mfg. Co. and General Electric Co. are described. GN (5.4)

The Wave-Length-Sensitivity Curve of a Cesium Oxide Photocell; a New Light-Sensitive Instrument for the Ultra-violet. T. F. Young & W. C. Pierce. *Journal of the Optical Society of America,* Aug. 1931, pages 497-501.

The construction and characteristics of a quartz-enclosed cesium oxide cell are described. Such a cell is very sensitive to ultraviolet light of very short wave lengths, at least as short as 2390A. (5.4)

Photoelectric Relays and Monorail System Speed Mail Handling. H. L. Bohm. *Steel,* Vol. 89, July 1931, pages 34-[illegible].

The article describes a photoelectric tube control for a monorail conveyor system designed to handle mail bags in a railroad terminal. The bags are moving with a speed of 450 ft. per min. and are dumped at the proper car for their destination by means of a stationary light adjusted to position at the car door. This light focuses on a photoelectric tube which previously has been set for some particular destination point at the dispatching station. This photoelectric tube by actuating relays and a magnet latch trips the carrier at the car for which it was set. Ha. (5.4)

A Method of Determining the Impedance of Hot Cathode Discharge Tubes. W. F. Westendorp, *The Review of Scientific Instruments,* Aug. 1931, pages 437-446.

By means of a superposed alternating current, the negative resistance of hot cathode neon and mercury direct current arcs was measured and found to follow closely the slope of the static characteristic of the neon arc, but to be widely different in the case of the mercury arc. At the same time the reactance for the ripple current in the arc was determined. This reactance is explained on the basis of a time lag in the concentration of metastable atoms; from the phase shift the order of magnitude of the lifetime of the metastable atoms is computed, and the result is in agreement with calculations made by others. (5.4)

Investigations on the Electron Current of the Cold-cathode Oscillograph. (Untersuchungen ueber den Elektronenstrom beim Kaltkathodenoszillographen.) E. Ruehlemann, *Archiv Elektrotechnik,* Vol. 25, July 15, 1931, pages 505-520.

The very exhaustive investigation into the performance of the cold-cathode oscillograph with pre-concentration and narrow discharge tube reveals that the intensity of electron ray bundle depends on the anode current, on the duration of the operation of the cathode, the material and the diameter of the latter, the gas contents, and the diameter of the hole in the diaphragm. All these influences have been measured and recorded. The quality of the record depends to a certain extent on the kind of coils used for diverting the bundle of rays; long coils are better than flat coils. Ha. (5.4)

A Sensitive Time Switch for the Cathode-ray Oscillograph. (Ueber eien empfindlichen Zeitkipper fuer den kathodenoszillographen.) H. Peek, *Archiv Elektrotechnik,* Vol. 25, June 19, 1931, pages 453-458.

The timing function of oscillographs has to be initiated for transient phenomena by the phenomena themselves, and that just in the instant when the phenomenon is to be recorded. This is done by an electron tube to which a voltage lower than the expected voltage of the phenomenon to be recorded is connected. As soon as the phenomenon takes place the tube responds, as it receives, due to the start of the phenomenon, a voltage sufficiently high to start it glowing. The general properties of such arrangements are described; the time for responding is about 1.5 x 10^{-6} sec. Ha. (5.4)

Beam-Triggering in the Cathode-ray Oscillograph. (Strahlsperrungen beim Kathodenoszillographan.) H. Boekels, *Archiv Elektrotechnik,* Vol. 25, July 15, 1931, pages 497-504.

In order to protect the photographic film against over exposure and to record the time axis only once, and that just at the time when the phenomenon is to be recorded, several devices have been developed. A most satisfactory method and acting almost instantaneously is that of Rogowski, which uses plates which deflect the cathode-ray in the inactive period and release it as soon as the phenomenon starts. All methods are fully described and illustrated, and 12 references are cited. Ha (5.4)

ACOUSTICS & VIBRATIONS (6)

Sound, Vibration Phenomena & Measurements (6.1)

A Concave Ultrasonic Diffraction Grating. George E. Thompson. *Review of Scientific Instruments,* June 1931, pages 332-335.

A Concave Ultrasonic Diffraction Grating and mounting have been used to measure ultrasonic wave lengths between 1 and 3 mm. An oscillating quartz crystal serves as generator and receiver of the waves. The results are compared with those obtained by the Pierce Interferometer and found to agree quite well. (6.1)

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Of instruments and devices for measurement, inspection or control

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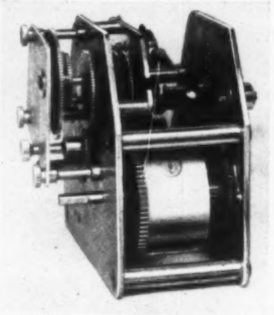

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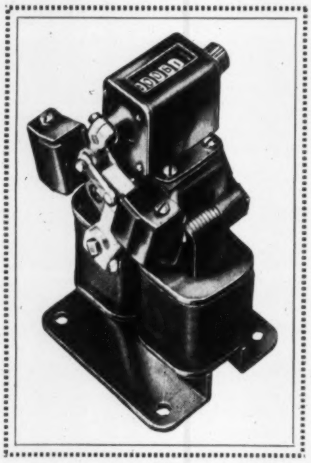

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